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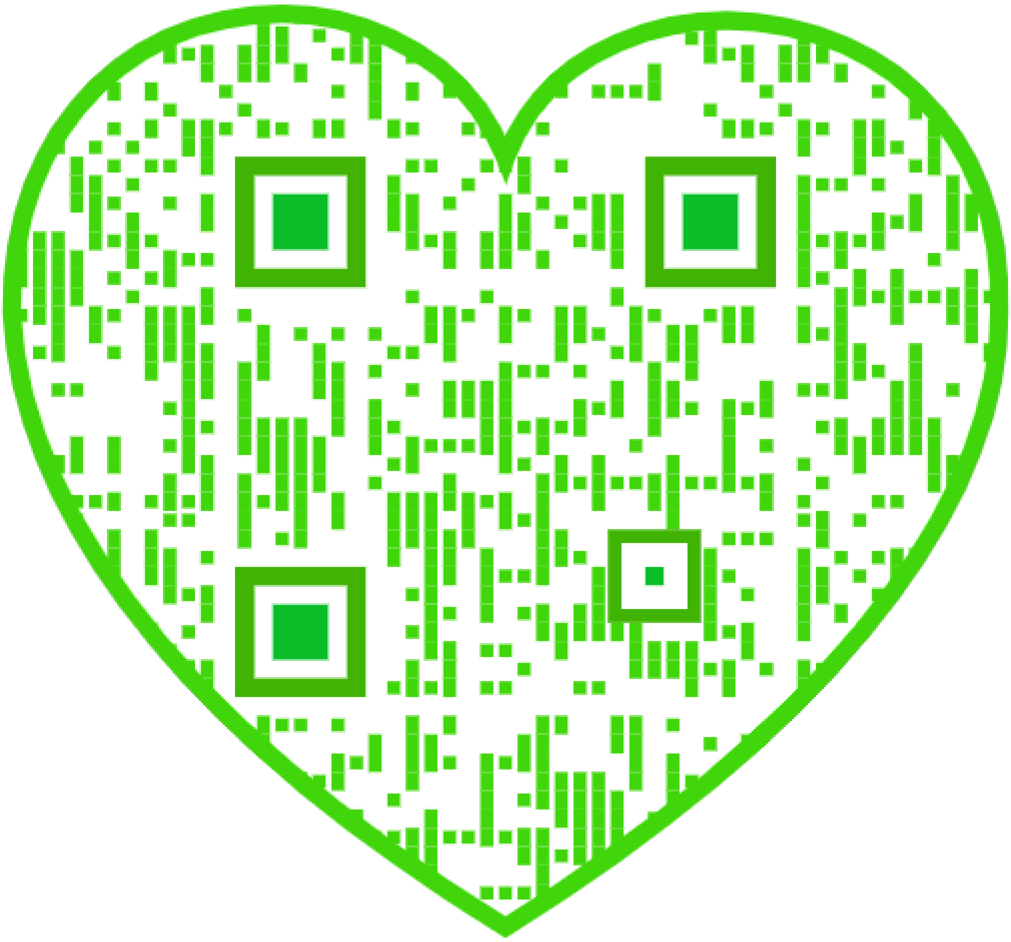

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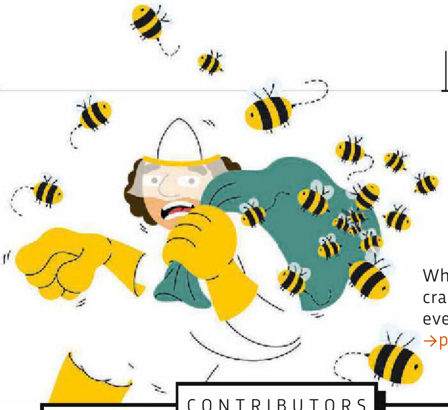

What's the craziest thing ever stolen? →p86

FROM THE EDITOR

I once saw someone's beating heart. Don't worry, the story isn't as grisly as it sounds. It was an ultrasound scan (also known as an echocardiogram): a video in black and white of my gran's heart. She had a leaky valve, which meant blood didn't always move around the chambers in one direction, as it should. Instead, each time the muscle relaxed, a flap in the heart wouldn't close tightly enough and blood would flow backwards.

The visual of a beating heart, on that screen, squeezing blood from one chamber into another, was probably one of the best biology lessons I had ever had. The textbook version of a heart, flat and motionless, didn't really equip me with me with a proper understanding of how it worked. This did.

Above all, I was struck by how tireless it was: contracting and relaxing in a precise rhythm without change. It was hypnotic. It's an image that stuck with me, but of course, the heart does tire – it just takes a few billion beats for it to happen. And for some of us, years of neglect means that it's likely to happen a little bit sooner.

So, how can we add some extra beats or, at the very least, make life a bit easier on the old ticker? Alongside all the usual advice (get some exercise, eat less bacon and so on) researchers are discovering that some surprising small changes can also significantly lower your risk of heart disease. And the good news is that they add up. Head to p60 to find out what we've uncovered.

Daniel Bennett

Daniel Bennett, Editor

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ON THE BBC THIS MONTH...

Mouth Organ
With new evidence suggesting that poor oral health can affect the whole body, Caroline Steel sinks her teeth into why the fields of dentistry and medicine have traditionally been kept separate.
Listen now on BBC Sounds

Winterwatch in Wales
Welsh ornithologist Iolo Williams, travels from Wales's rugged coast to its cities, to find out how animals seek refuge in winter.
Watch now on BBC iPlayer

Health Check:
The global oxygen crisis
Oxygen shouldn't be a privilege. A world-first report has revealed the countries at risk of suffering a medical oxygen shortage and the steps we need to take to keep the global supply chain accessible.
Listen now on BBC Sounds

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SOPHIE FREEMAN
Looking for ways to improve your heart health? Science writer Sophie rounds up seven of the simplest changes you can make to keep it beating a steady rhythm. →p60

PROF GILES YEO
By building a map of the brain's appetite control pathways, geneticist Giles and his colleagues hope to find new ways to treat obesity. →p26

PHILIP BALL
Philip, a science author and a former editor of *Nature,* takes us on a whistle-stop tour of the weirdest wonders the quantum world has to offer. →p46

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Christian, a psychologist and author, delves into the strange things that happen in the brain during a near-death experience. →p52

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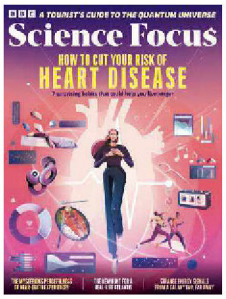

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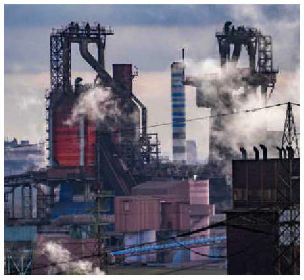

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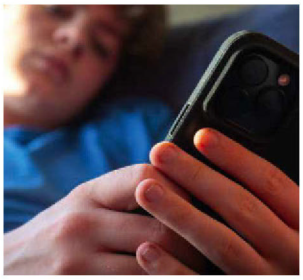

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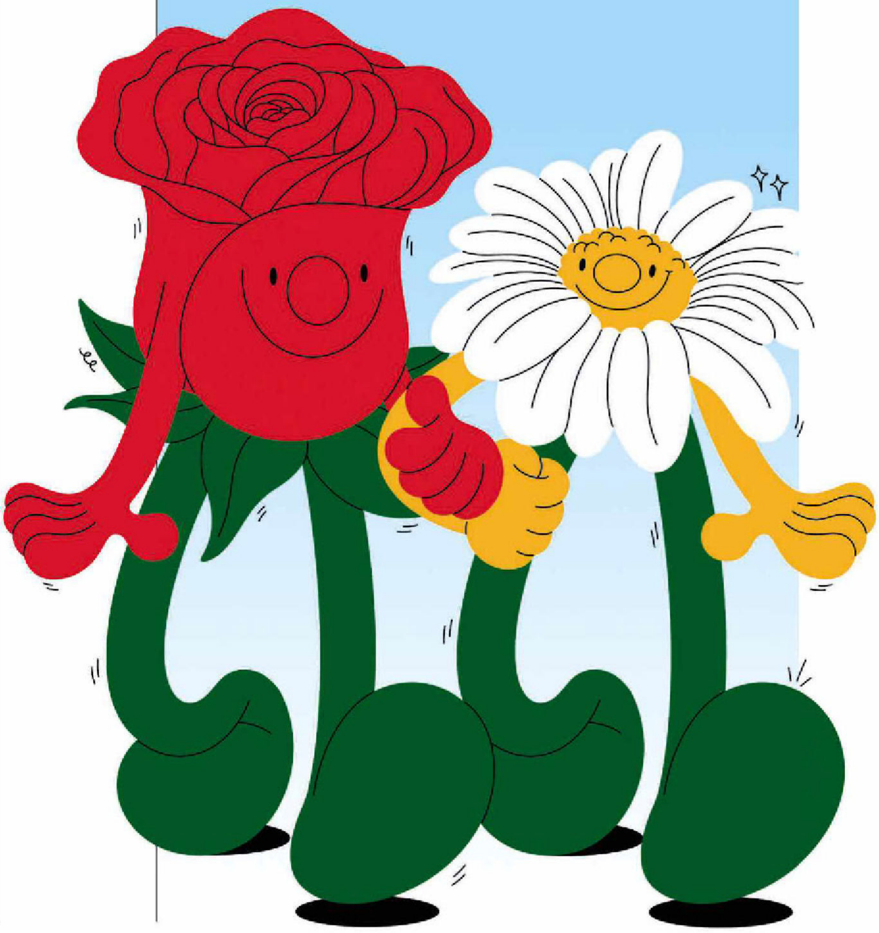

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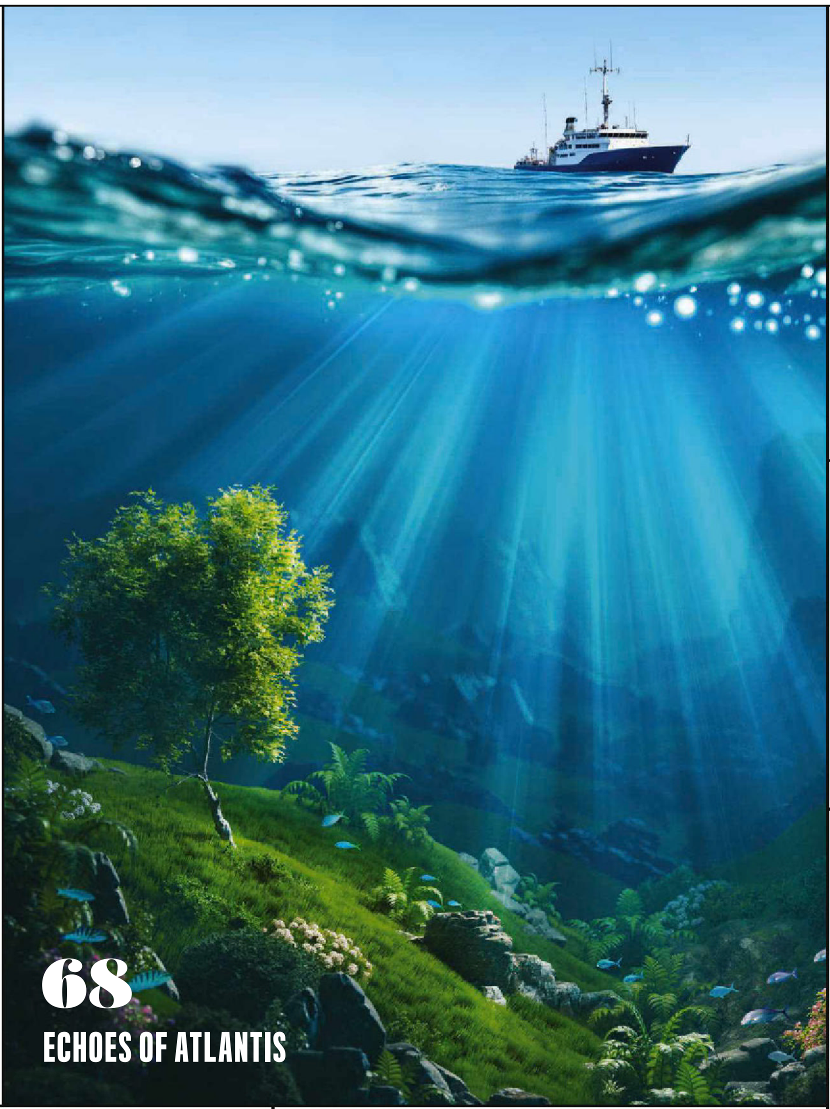

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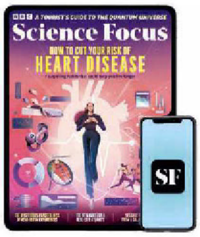

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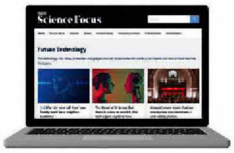

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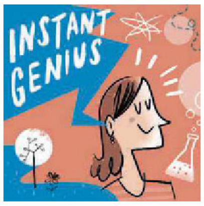

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EYE OPENER

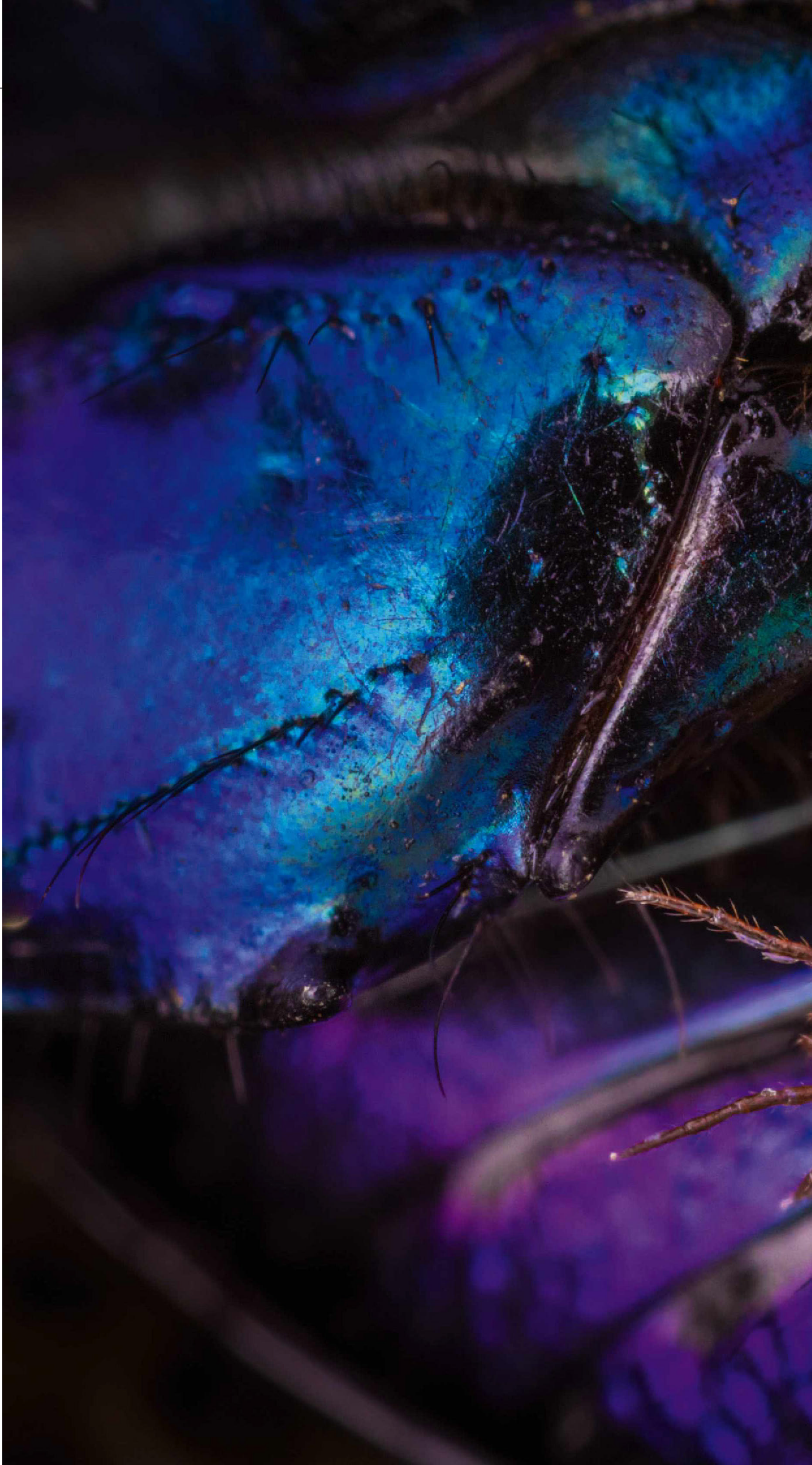
Hitch a ride

DERBYSHIRE, UK

Symbiotic relationships show nature in harmony, how two species can mutually benefit each other as part of the complex tapestry of life. They can also be pretty gross, as demonstrated by the partnership between the phoretic mite and the dor beetle.

The opportunistic phoretic mites (*Poecilochirus carabi*) use the beetles as a kind of public transport system. The orange mites hitch a ride on the bigger insects' backs, wings or abdomens (as seen here) to the dor beetle's favourite brunch spot: a fresh, steaming pile of dung. While the dor beetle tucks into the mouth-watering manure, the mites feast on fly larvae that's been laid among the faeces. Beetles naturally compete with flies for the delicious droppings, so the mite's choice of meal broadly benefits the insects providing the transport service.

Dor beetles (*Geotrupes stercorarius*) are one of the most familiar of the UK's 60 dung beetle species and are commonly found on farmland or pasture, places rich in horse and cow excrement. You might not expect dung beetles to be particularly fussy eaters, but a 2007 study published in *Ecological Entomology* found they're actually surprisingly picky. They favour herbivore droppings, which are high in nitrogen and low in carbon.



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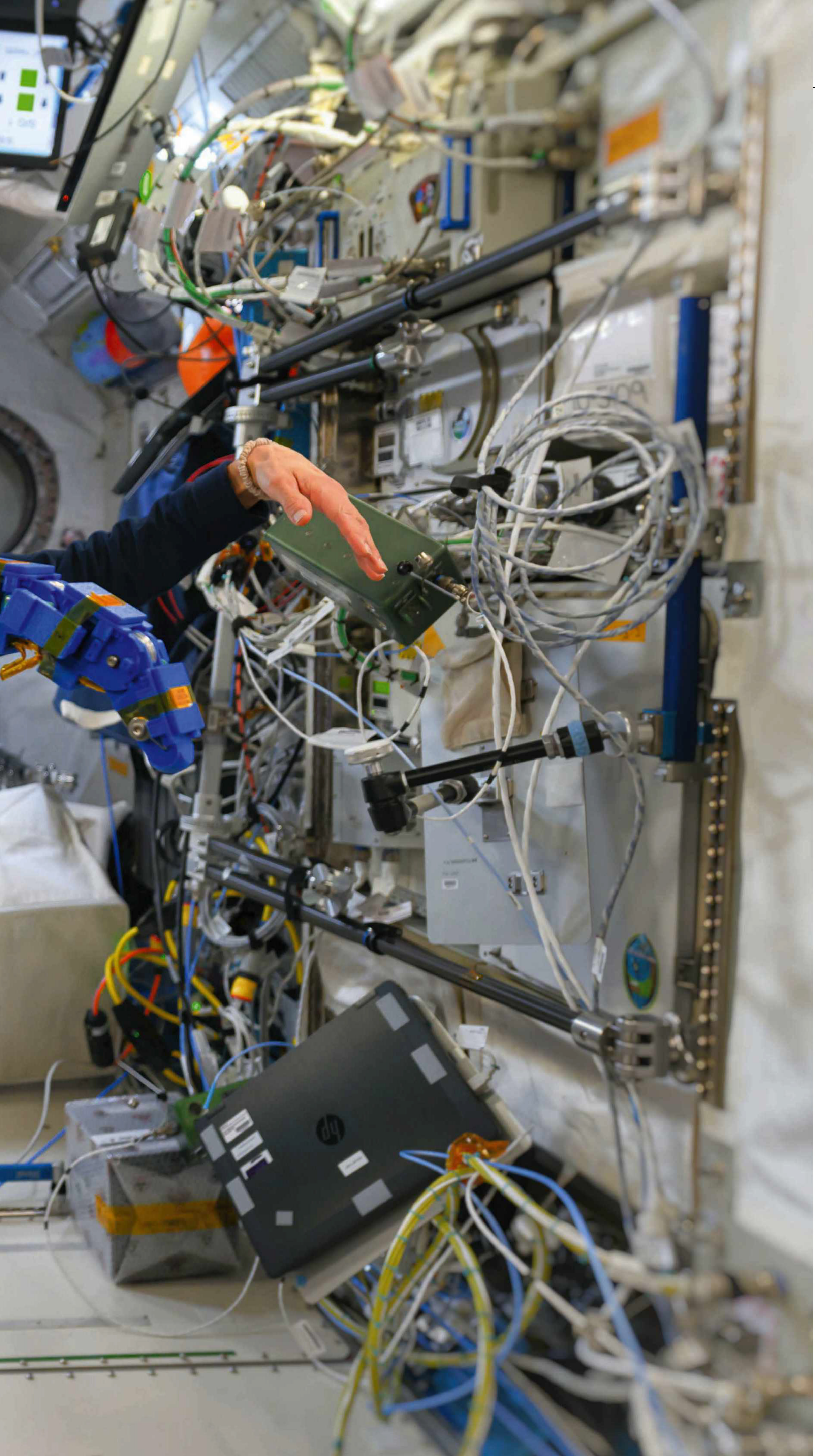

EYE OPENER

A helping hand

INTERNATIONAL SPACE STATION

The cube floating at the front of this image is one of three Astrobees – semi-autonomous robots that fly around inside the International Space Station (ISS) helping astronauts with routine duties (think 'busy work', such as taking inventory, filming experiments and moving cargo). But this one's just had an upgrade, in the form of those blue, tentacle-like appendages protruding from its top.

The Responsive Engaging Arms for Captive Care and Handling (REACCH) system is being developed to handle satellite maintenance. For now, however, it's being put through its paces inside the ISS – under the watchful eye of NASA astronaut Sunita Williams, the commander of Expedition 72.

REACCH's design consists of four flexible arms that can extend and embrace objects regardless of their shape. On the end of each arm is an adhesive pad, inspired by a gecko's fingertips, to help it grip anything it grabs. In tests, REACCH has been able to catch items, including flat panels of aluminium and acrylic, as well as rough, textured objects.

Researchers hope to put REACCH to work servicing satellites in low Earth orbit to extend their lifespans, as well as remove debris from their paths.

NASA

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EYE OPENER

The aftermath

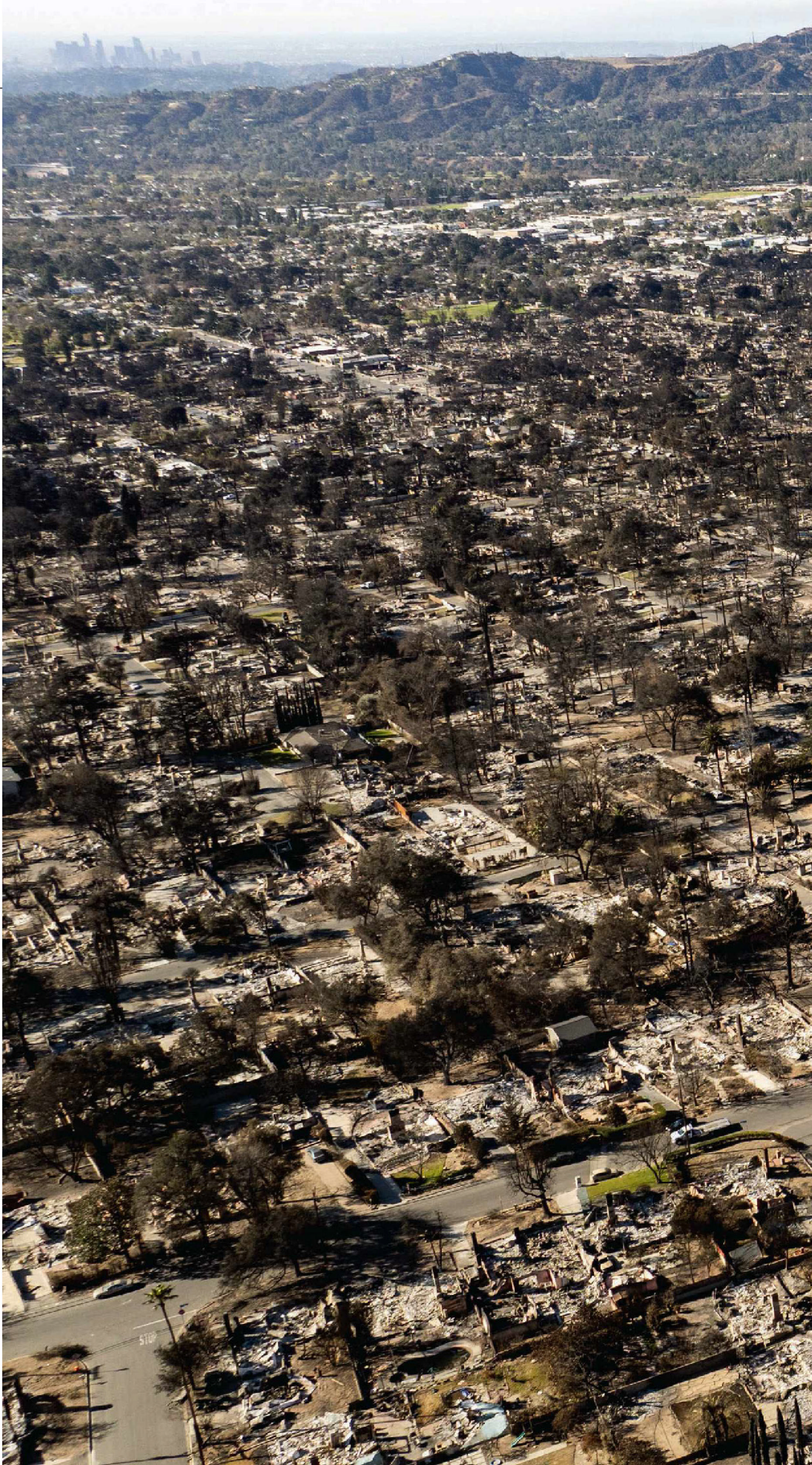
ALTADENA, CALIFORNIA

California is no stranger to wildfires, but that doesn't make images like this any less shocking. This is what was left of Altadena, an area that lies almost 25km (15 miles) north of downtown Los Angeles, after the Eaton fire – one of many to hit southern California – swept through in January.

One of the most destructive wildfires in California's history, the Eaton fire decimated almost 57km^2 (over 14,000 acres) of land, destroyed 9,413 structures and took firefighters 24 days to contain.

A perfect storm of conditions combined to increase the fire's devastation. For one thing, the surrounding scrubland had been left tinder-dry, due to a lack of any measurable rainfall over the preceding eight months. But the Santa Ana Winds – an annual occurrence that sees hot desert winds gusting at speeds of 160km/h (100mph) towards the coast – also helped the blaze to spread quickly.

With climate change expected to further disrupt weather patterns in future, calls are mounting for measures, such as controlled burns and forest management, to help reduce the damage such fires can cause.



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LETTER OF THE MONTH

A light lunch

In the Q&A titled 'How much weight fluctuation is normal?' (February, p86), Dr Nish Manek says that eating food adds to your weight for a short time as it travels through your digestive system.

I used to work at a health centre, where I used scales to determine a patient's weight. One day, I weighed myself before lunch while holding my sandwiches and cake (minus the packaging and plates). Immediately after eating, I weighed myself again to see if it would be the same – only to find that I was three whole grams lighter than I had been before eating.

Fred Bellamy, Bath

WRITE IN!

The writer of next issue's Letter of the Month receives a pair of popular science books: **The Housefly Effect** *and* **Interstellar**.

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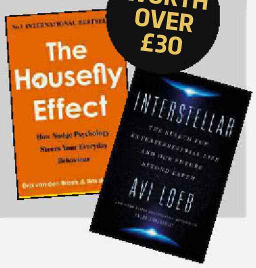


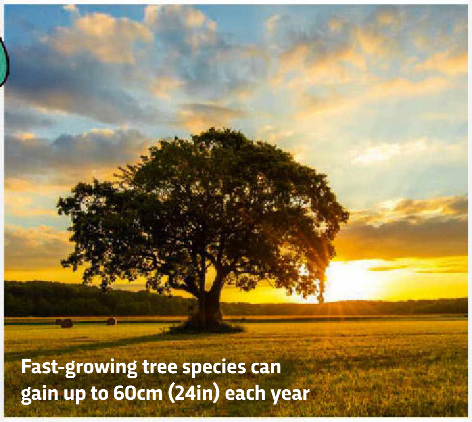
JAMES CLAPHAM, GETTY IMAGES

Barking up the wrong tree

I was intrigued by Tom Jones's letter about how he observed the Sun setting at a different spot on the treeline over the years (January, p12).

The explanation put forward by your colleagues on *BBC Sky at Night Magazine* is convincing, but surely the answer is quite simple: over the last 45 years that Tom has lived at that house, the trees will have grown considerably. The Sun still sets in the same place but only appears to do so on the left of the original point because it reaches them earlier than 45 years ago.

Bill Little, via email



Fast-growing tree species can gain up to 60cm (24in) each year

What's in the water

In the Q&A titled 'What exactly do water filters filter out?' (December, p87), expert Ceri Perkins lists the substances that filters catch, and points out they struggle to catch things like nitrates, bacteria and viruses, as well as heavy metals such as arsenic and mercury.

But that list should also include fluoride as the only type of filter that removes fluoride is a reverse osmosis filter. Not that we necessarily want it filtered out, however: if water is fluoridated, that's good news. Fluoridation of a water supply reduces dental problems in the community.

Dr Amar Davé, Illinois, USA

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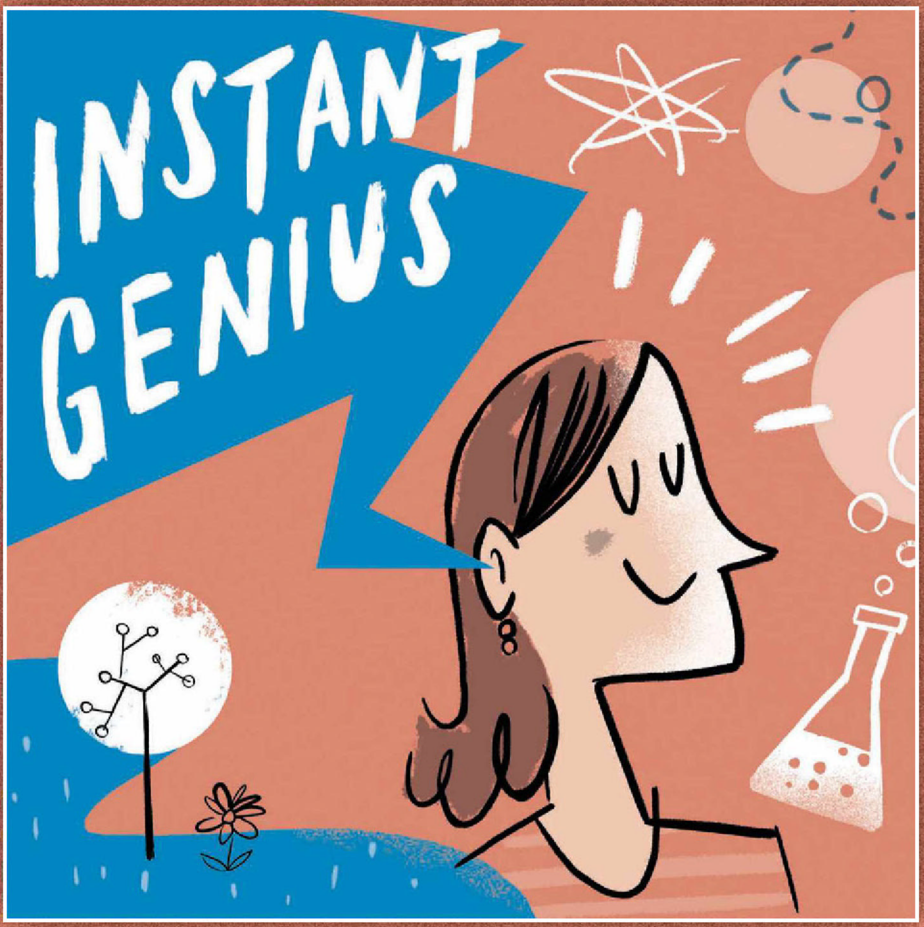

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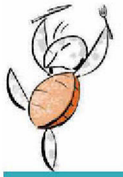

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WORLD'S GREATEST DADS

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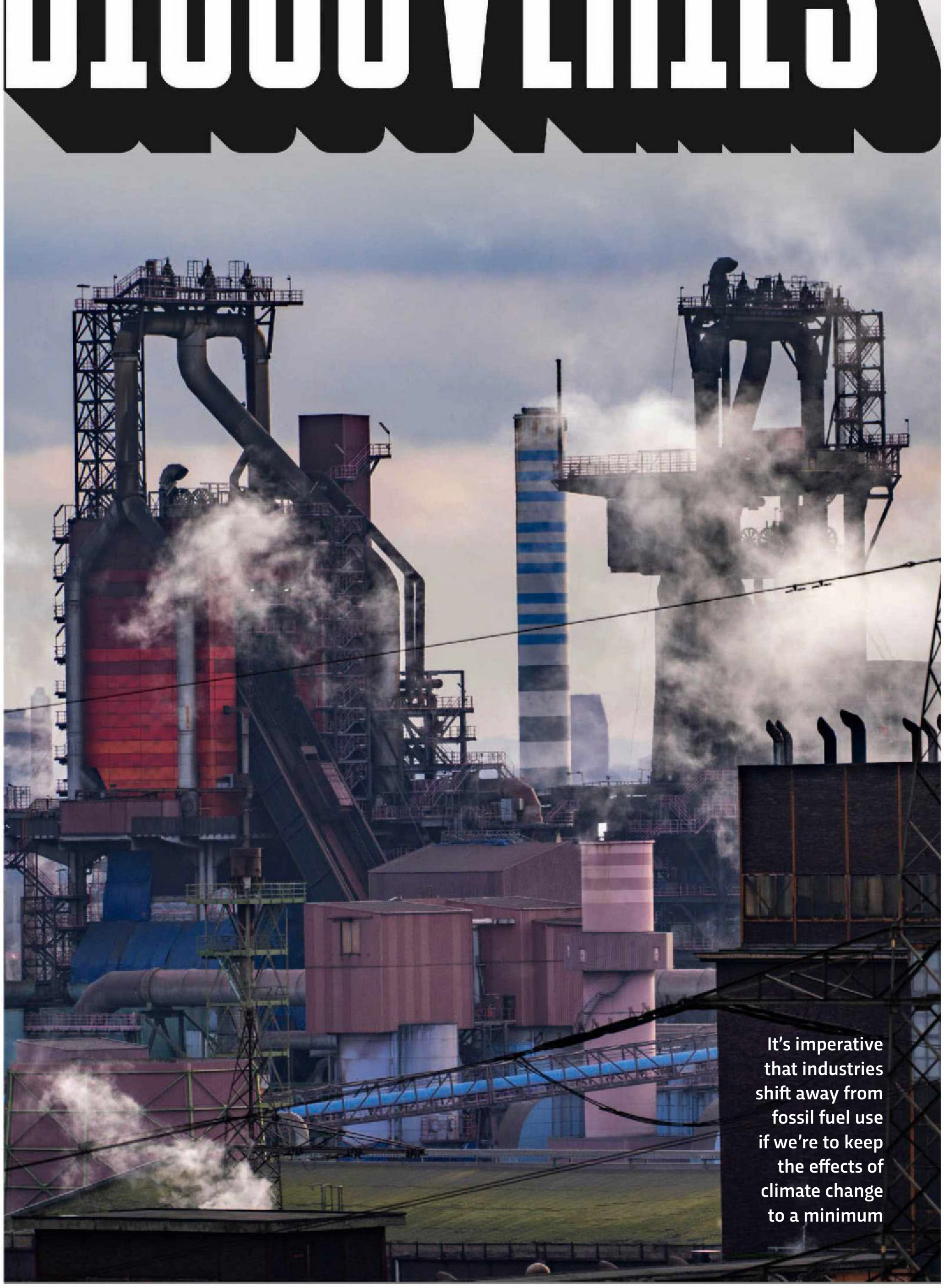

It's imperative that industries shift away from fossil fuel use if we're to keep the effects of climate change to a minimum

CLIMATE

Energy companies shift blame to consumers

Study finds top polluters weave 'eco-hero' narratives

Making changes to your everyday life can feel like you're playing a part in making the future more environmentally sustainable. But new data suggests that storytelling by energy organisations often places an unrealistic burden on consumers to be heroes in the climate change narrative, absolving the industry of its responsibility. Meanwhile, individuals' actions pale in comparison to the impact of big businesses.

"We need to be much more careful about how we talk about this," says Dr Tom van Laer from the University of Sydney Business School in Australia, who authored the study published in the *Journal of Public Policy & Marketing*.

Globally, the energy sector is the largest contributor to carbon emissions. So van Laer wanted to check how accurately energy organisations in his country – responsible for almost half of Australia's national emissions – frame their role in this.

His team pored over 300 different communication materials from 44 →

ALAMY

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BELOW Some recycling practises are inconvenient for people short on time

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Don't recycle at home

> "It's still really about the infrastructures that all of us live within, those are really what determines what we're able to do"

→ Australian energy organisations – from energy providers to non-government policy regulators – between 2015 and 2022. Being a narratologist (an academic who studies storytelling and its influence) van Laer specifically analysed the materials' use of 'characters' and their role in the story.

THE ONE THING

The conclusion: most energy communications initially addressed what the organisations are doing to improve, "but then they very quickly say, 'But the consumer should really start taking this stuff seriously'," van Laer says. "It's a nice little twist."

From preferred methods of personal transportation to the use of utilities, van Laer found that marketing materials from these bodies regularly redirect the focus to consumer choices. For instance, marketing material by the Australian Energy and Water Ombudsman, which has yet to respond to our request for comment, says there's a "new role for consumers within the broader energy system."

Similarly, the world's first 'individual carbon footprint calculator' was designed by the energy provider BP. This is likely encouraging people to scrutinise their own carbon footprints instead of looking at BP's, says van Laer. (BP has yet to respond to our request for comment.)

The overall pattern is the rise of a 'hero's journey' narrative, says van Laer, which he compares to Tolkien's *The Lord of the Rings*, in which Frodo embarks on a gruelling journey to save Middle Earth from the forces of Sauron.

These narratives, which shift the responsibility onto consumers, are pervasive the world over, whether it's about emissions, plastic pollution, or food waste, says Dr Claudia Gonzalez-Arcos, a sustainability

ALAMY, GETTY IMAGES X3

ABOVE Our continued reliance on fossil fuels is endangering the planet's climate

marketing expert from Pontificia Universidad Católica in Chile. "We see it everywhere and it's more normalised than ever before," she says. But research shows they actually often backfire.

ACCEPTING RESPONSIBILITY

Gonzalez-Arcos's team analysed consumer responses to a nationwide ban on plastic bags in Chile in 2019. They found that consumers have experienced "physical, psychological and philosophical discomfort" as well as strong emotional reactions of guilt, betrayal and anger.

"They resist this responsibilisation because they feel they're the only ones taking the weight of climate change," says Gonzalez-Arcos. "Placing a moral responsibility [onto someone] means that you're [introducing] a lot of emotionality into a practice."

This delays individual action. "Consumers hesitate to commit," says Gonzalez-Arcos. "Particularly because they don't see commitment from other actors whom they wish to share responsibility with."

She cites the example of bakery chain Panera's initiative to launch pay-what-you-want cafés in the US in 2010. The idea was that customers in need could eat meals in exchange for donations, while wealthier customers would feel morally incentivised to 'pay it forward'. Yet the cafés could never break even. Research on food waste schemes in England found similar results, where people were being blamed for their actions, and as a result felt disincentivised.

"It's still really about the infrastructures that all of us live within, those are really what determines what we're able to do," says Prof Peter Newell, a political economist of environmental development at the University of Sussex, who wasn't involved in either study.

Data confirms, time and time again, that individual action has a much smaller impact than that of corporations. For instance, the Carbon Major Database from 2024 suggests that 57 oil, gas, coal and cement producers are directly linked to 80 per cent of the world's carbon emissions over the past nine years.

Shifting the burden of responsibility onto consumers assumes people have endless choices and the power to do things differently. Some people can afford that luxury of choice, says Newell, but "it's not true of most people."

In fact, data collected by charity OXFAM suggests the top one per cent of the wealthiest people in the US emit 25 times as much carbon pollution as people in the bottom 50 per cent. Studies also note the wealthiest 10 per cent of Americans – households making more than $178,000 (about £140K) – are responsible for about 40 per cent of the nation's carbon emissions.

"There's a sort of blame game that often goes on in these debates, which easily comes down to the individual," says Newell. "Actually, these responsibilities are collective."

GEOSCIENCE

Earth's inner core may be changing its spin and its shape

Changes to seismic waves travelling through the planet could reveal unusual activity in Earth's core

GETTY IMAGES

> **"The research shows that, in 2010, Earth's inner core went from rotating faster than the rest of the planet, to slower"**

It's not unusual for Earth's core to change its rate of rotation or even its shape over time – though, as far as scientists could tell, never simultaneously. But new research reveals that something unexpected may be happening deep beneath our feet.

Scientists have long debated the cause of strange changes to the seismic waves triggered by earthquakes when they ripple through the planet's core. One side argued the core's rotation rate delays or accelerates the travel time of the waves, while the other claimed that it's deformation of the inner core causing changes in the waves. In the new study, published in journal *Nature Geoscience*, scientists from China and the US reveal that it's likely to be both.

The research shows that, in 2010, Earth's inner core went from rotating faster than the rest of the planet, to slower. This – along with changes near the surface of the inner core – likely interrupted the seismic waves. Like X-rays as they pass through our flesh and bones, these waves allow scientists to 'see' what's happening inside the planet. The researchers think the discovery could help us unlock more information about the core's properties and structure.

"For now, these findings simply provide an observable change that might lead us to get a clearer picture of how the inner core is flexing on a timescale of years. Further surprises may await," John Emilio Vidale, a professor of Earth Sciences at the University of Southern California Dornsife, and the lead author of the study, told *BBC Science Focus*.

At around 5,200°C (close to 9,400°F) Earth's inner core is almost as hot as the surface of the Sun. It also begins roughly 5,100km (3,200 miles) beneath the planet's surface and has a higher pressure than the deepest parts of the ocean. In other words, there's no way to directly access the core and study it.

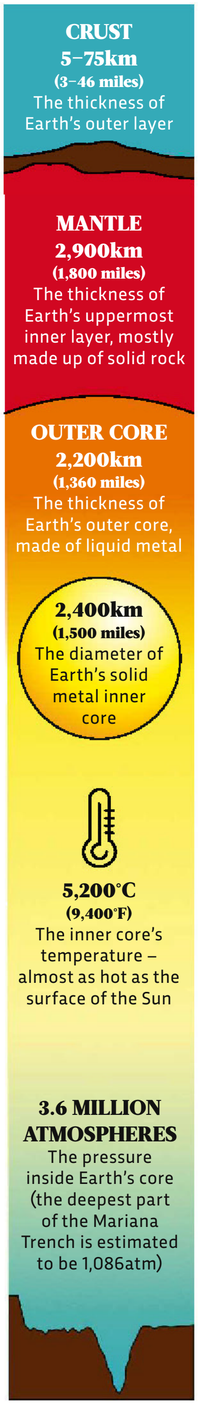
Instead, scientists study seismic waves caused by earthquakes. By examining how these waves travel through different layers of the planet, scientists can better understand the structure, movement and behaviour of the core.

In this latest set of research, the team looked at seismic waves from 121 repeating earthquakes (earthquakes that occur in the same place, but at different times) in the South Sandwich Islands between 1991 and 2023. These earthquakes were recorded at two seismic arrays: one in Eielson in Alaska, in the US, and the other in Yellowknife, in Canada.

By looking at the arrival times and changes of these seismic waves over multiple decades, the team could detect minor shifts in the core's movement. If the inner core was rotating steadily, the arrival times of the seismic waves would shift consistently over time.

The study's findings showed a few noticeable trends in Earth's inner core. It rotated faster than Earth's mantle and crust for several decades, before slowing down around 2010. But some earthquakes showed no significant time shift, suggesting that the rotation paused or reversed at times.

The study had a secondary finding: due to differences in the signals coming from the two seismic arrays, the team was able to detect that something other than rotation was affecting the inner core.



CRUST
5–75km
(3–46 miles)
The thickness of Earth's outer layer
MANTLE
2,900km
(1,800 miles)
The thickness of Earth's uppermost inner layer, mostly made up of solid rock
OUTER CORE
2,200km
(1,360 miles)
The thickness of Earth's outer core, made of liquid metal
2,400km
(1,500 miles)
The diameter of Earth's solid metal inner core
5,200°C
(9,400°F)
The inner core's temperature – almost as hot as the surface of the Sun
3.6 MILLION ATMOSPHERES
The pressure inside Earth's core (the deepest part of the Mariana Trench is estimated to be 1,086atm)

The team behind the study thinks viscous deformation near the inner-core boundary might be the culprit. Though the inner core is made of solid metal, variations in the shape of the outer core or changes in the mantle's density can change the inner core's structure.

While this behaviour is seemingly erratic, there currently isn't enough data to confirm whether this is normal or not – and therefore get a clear picture of how Earth's core is really behaving.

According to Vidale, the simplest explanation is that the outer core's movements initiate the inner core's rotation, effectively realigning the inner core over decades. The exact mechanism by which this happens is uncertain, however.

"If this was the case, the rotation of the cores would be mostly harmonic [predictable]," he said. Alternatively, "the inner core motion could be mostly chaotic, just going in the direction the outer core goes."

For now, this research remains an interesting analysis of the behaviour of Earth's core, but it could lead to more discoveries. Vidale notes that further analysis could show when and where outer core convection is most vigorous, or where the inner core is more or less soft.

He also believes there's a chance it could reveal a link between inner core changes and unpredictable jerks in Earth's magnetic field. While these don't affect our everyday lives directly, they can affect satellites and compasses.

HEALTH

Prioritise regular sleep patterns over total hours, says study

A bad bedtime routine is more dangerous than a lack of sleep

The measurement most often used to gauge a good night's sleep is the number of hours of shuteye we get. And although getting plenty of sleep is definitely important, what we should be paying more attention to is our bedtime routine.

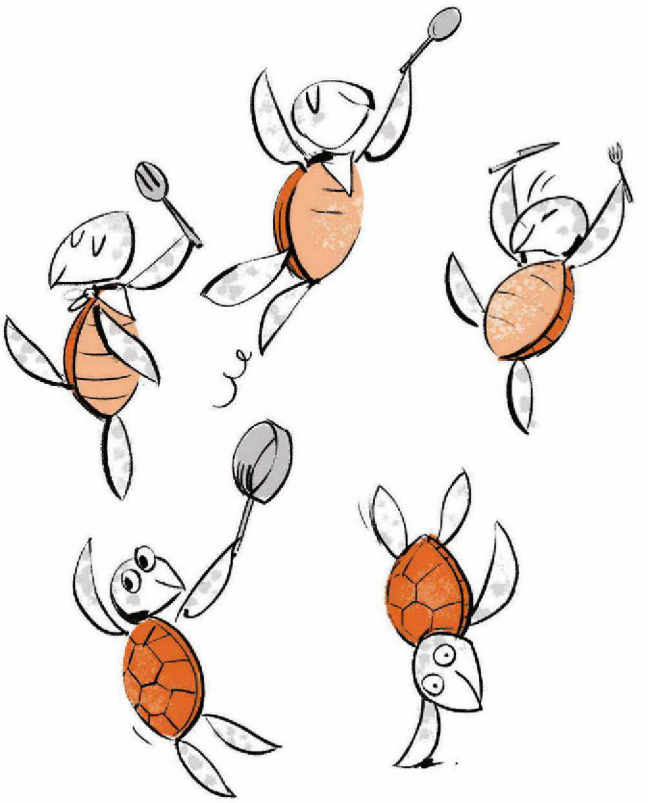
That's according to a new study published in the journal *Sleep*. It suggests that a person's sleep regularity (the consistency of their sleep-wake timing) is a stronger predictor of mortality risk than sleep duration. Even people who manage to sleep consistently for seven to eight hours each night, but who keep irregular schedules, are at a higher risk of strokes, heart attacks and cancer than those who slept fewer hours, but maintained a more consistent schedule.

Now, this doesn't mean you can get away with only a few hours of sleep every night, staying up as long as you want before regularly crawling into bed at 3am. The findings of the study show that those who got under six hours of sleep, or over nine, each night were at an increased risk too.

Researchers analysed sleep data from almost 61,000 people in the UK Biobank, a biomedical database tracking the health of half a million people in the UK. In total, they examined more than 10 million hours of recorded sleep. Using advanced algorithms to study sleep patterns and tracking people's death rates over an average of 6.3 years, they identified the factors linked to a higher risk of early death.

Overall, the people who had the most consistent sleep-wake times had up to a 48-per-cent lower risk of all-cause mortality compared to those with the least consistent routines.

The researchers hope these findings will help update public health guidelines and sleep recommendations. Given the risks, they believe advice should focus not just on getting enough sleep, but on maintaining a regular schedule for better overall health.



NATURE

Turtles dance when they get near feeding sites

The adorable behaviour may unlock the secrets to their powers of navigation

Turtles are known for their extraordinary navigation abilities – they're capable of travelling across oceans to return to the same nesting and feeding grounds throughout their lives. In fact, their skills are so good that it puts them in the mood to dance.

A new study, published in *Nature*, has revealed that baby loggerhead turtles perform a lively jig when their preferred places to feed are nearby. The discovery suggests that they use magnetic fields as signposts, detecting the unique signatures of a particular feeding ground and celebrating when they find them.

ILLUSTRATIONS: ADAM GALE

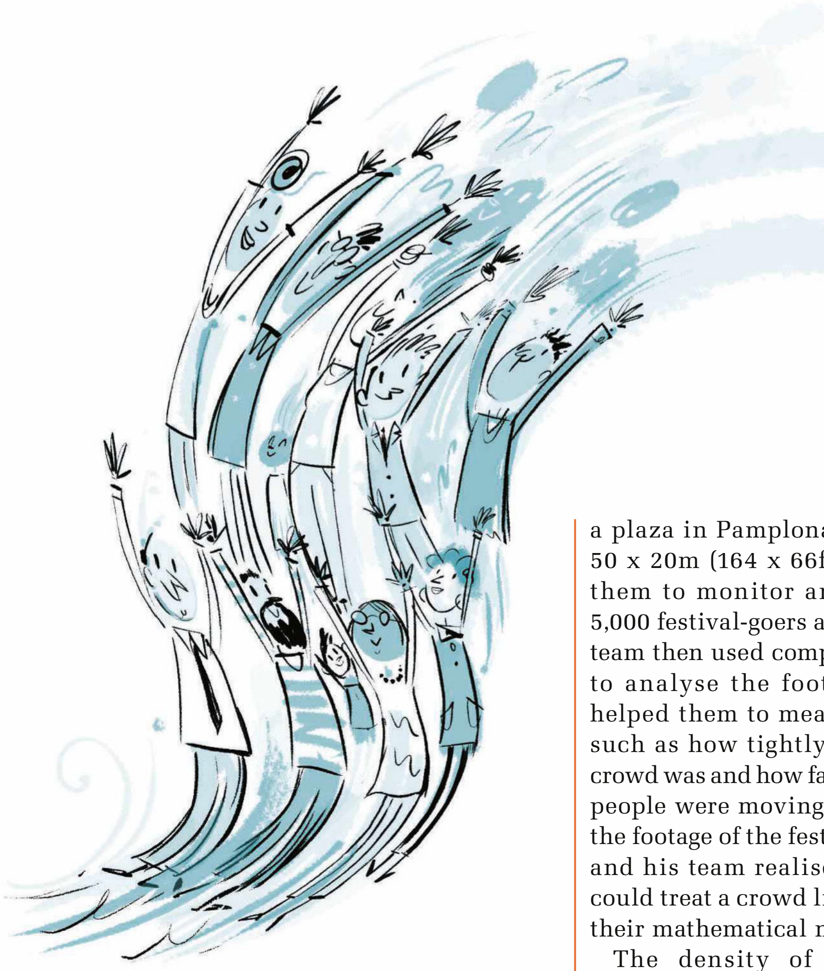
The turtles' dance moves include tilting their bodies vertically, holding their heads above the water, opening their mouths, waving their front flippers and spinning in place.

Researchers prepared two water tanks to match the magnetic signatures of two locations – a site in the Gulf of Mexico and another near New Hampshire, in the US – and conditioned the turtles to associate one with food. They found that there were significantly higher levels of turtle dance behaviour when in the feeding tank, even if there was no food, suggesting that the loggerheads could distinguish between the magnetic fields. Even months later, the turtles continued to recognise the feeding tank.

"Sea turtles can detect both intensity [of the magnetic field] and inclination angle [the angle that magnetic field lines intersect with Earth's surface]," study author Dr Kayla Goforth told *BBC Science Focus*. "These two components vary predictably across the globe and turtles use this to determine map information."

The researchers plan to explore this 'magnetic map' ability further. "We would like to delve into what the mechanism of the map might be, as well as look at the sensitivity of the magnetic sense," said Goforth. "What's the smallest difference in magnetic field turtles can detect?"

> "Turtle dance moves include tilting their bodies vertically, waving their front flippers and spinning in place"



PHYSICS

Crowds of people act like liquids

Researchers observe human 'ripples'

Ever heard a large crowd being referred to as a 'sea of people'? Well, the phrase might be more appropriate than you think, according to a team of Spanish scientists led by Prof Denis Bartolo.

By observing people at the opening ceremony of the San Fermín festival in Pamplona, Spain – best known for the Running of the Bulls – the team found that extremely dense crowds behave like liquids. When sharing the same limited space, people would move in predictable and fluid 'ripples'.

In 2019 and from 2022–2024, the scientists placed two cameras over a plaza in Pamplona measuring 50 x 20m (164 x 66ft), allowing them to monitor an estimated 5,000 festival-goers at a time. The team then used computer models to analyse the footage, which helped them to measure factors such as how tightly packed the crowd was and how fast individual people were moving. Examining the footage of the festival, Bartolo and his team realised that they could treat a crowd like a fluid in their mathematical model.

The density of the crowd increased significantly during the opening of the festival, from two people per square metre (10.8 square feet) to six. When an upper limit of nine people per square metre had been reached, pockets of several hundred festival-goers could be observed moving at regular intervals of approximately 18 seconds.

This movement creates the effect of ripples through the crowd, with people shifting in almost perfect harmony despite being several metres apart. Of particular interest to the researchers was the fact that these regular ripples of motion happened naturally, without being caused by any outside force, such as people pushing each other.

Bartolo and his team hope their research can address safety concerns at large events. Having hundreds, if not thousands, of people packed into a small area can be dangerous, potentially leading to crushing, suffocation and, in extreme cases, death.

SPACE

Bennu asteroid could spark a global winter if it hits Earth

Scientists warn of profound affects of a collision in 2182

The asteroid Bennu has been the talk of the scientific community since samples from its surface were collected, returned and analysed. But while those investigations revealed the asteroid hosts all the building blocks of life, an alarming discovery has been made about its trajectory: Bennu could hit Earth.

Based on modelling estimates, scientists believe there's only a 1-in-2,700 chance of a collision. But, according to a study published in the journal *Science Advances*, its impact could launch as much as 400 million tonnes of dust, debris and ash into the planet's atmosphere. This could block out the Sun, cooling Earth by 4°C (7.2°F) and triggering a global winter. Less sunlight would spell disaster for Earth's plants and, in turn, other forms of life, while disruption to the water cycle would result in a reduction of rainfall by 15 per cent.

In short, experts think Bennu could have a profound effect on humanity. "Asteroid impacts have taken place many times in Earth's history," said one of the study's authors Dr Lan Dai of Pusan National University, in South Korea. "Our early human ancestors may have experienced some of these planet-shifting events before, with potential impacts on human evolution and even our own genetic makeup."

There's a glimmer of hope, however. Even if the odds line up, the estimates place the date of Bennu's impact with Earth at 2182. This gives us 157 years to map its progress and prepare a defence.

HEALTH

Omega-3 might slow your biological clock

A new study has shown that the supplement can knock months off your body's age

There are so many supplements claiming to help you defy the ageing process that it's easy to think a veritable home pharmacy is needed to keep you healthy into old age. But a new study points to just one supplement that can have a real benefit to your longevity: omega-3. Regular capsules of the fatty acid could slow down your biological ageing. Unlike chronological age (the number of birthdays you've had), biological age is a more accurate predictor of lifespan as it reflects the rate of change in your DNA.

For the study, published in the journal *Nature Ageing*, an international team of researchers compared the effects of omega-3 against vitamin D and regular exercise in over 700 adults aged over

ILLUSTRATIONS: ADAM GALE

BIOLOGY

Breakthrough in genetic engineering creates mice with two dads

The news sparks questions about the future of reproduction

In a scientific first, mice created with two male parents have successfully reached adulthood. The advance in embryonic stem cell engineering, which enabled precise modification of reproductive genes, overcame barriers previously thought insurmountable in unisexual reproduction in mammals.

In past experiments, mouse embryos stopped developing early as a result of genetic issues during fertilisation from two male mice, leading to severe birth defects. The researchers behind the new study suspected that these issues were caused by 'imprinting' genes, which must be inherited from both a male and female parent, typically.

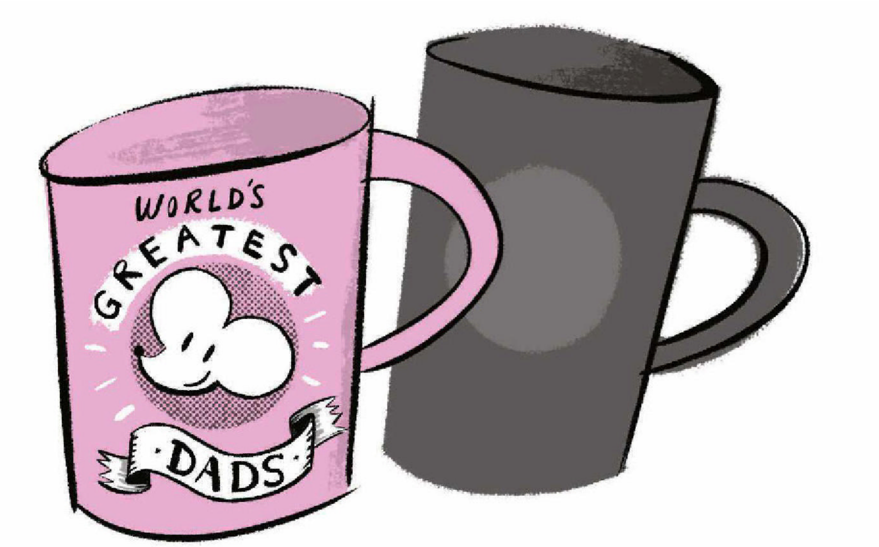
"The unique characteristics of imprinting genes have led scientists to believe that they're a fundamental barrier to unisexual reproduction in mammals," said Prof Qi Zhou, Vice President of the Chinese Academy of Sciences and one of the authors of the study.

The researchers modified 20 key imprinting genes before implanting the altered embryos into surrogate mothers. Their findings revealed that these genetic edits not only led to the successful birth of bi-paternal mice, but, in some cases, allowed them to survive to adulthood.

"This approach can significantly improve the developmental outcomes of embryonic stem cells and cloned animals, paving a promising path for the advancement of regenerative medicine," said Prof Guan-Zheng Luo of Sun Yat-sen University, China, another of the study's authors.

But it wasn't all good news. Only 11.8 per cent of viable embryos developed to birth, and most of the mice that did reach adulthood had abnormal growths and shorter lifespans, or were sterile.

Yet it's a significant step and the team is working to fix these problems by studying how changing certain genes could help embryos develop better. They plan to test their research on larger animals, like monkeys. Until then, it's unclear whether this technology could be used for humans.



> "This approach can improve the developmental outcomes of embryonic stem cells and cloned animals"

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70. Over three years, the participants – all living in Switzerland – were given a certain combination of omega-3, vitamin D, exercise, or none, while giving blood samples and using epigenetic 'clocks' to determine their rates of ageing. At the end of the trial, three of the four clocks revealed that the biological age of those taking omega-3 was reduced by four months.

In previous studies, the same team showed that the supplement reduced signs of ageing when combined with either vitamin D or exercise. The strongest results appeared when all three were combined, lowering cancer risk and preventing frailty in participants.

"It's exciting to see these results showing the benefits of omega-3, vitamin D and exercise on ageing," said Dr Mary Ni Lochlainn, a post-doctoral research fellow in geriatric medicine at King's College London, who wasn't involved in the study. "While the study was focused on healthy and active older adults, and led to a relatively small improvement in their ageing-biological-clocks, it adds to the growing evidence that these simple and fairly low-cost interventions are beneficial."

EARTH

A glimpse into the future of space-born surveillance

New mapping by ESA satellites could track everything from natural disasters to illegal activity

Beyond what appears to be a landscape splotched with tie-dye, this image marks a turning point in ultra-precise Earth mapping.

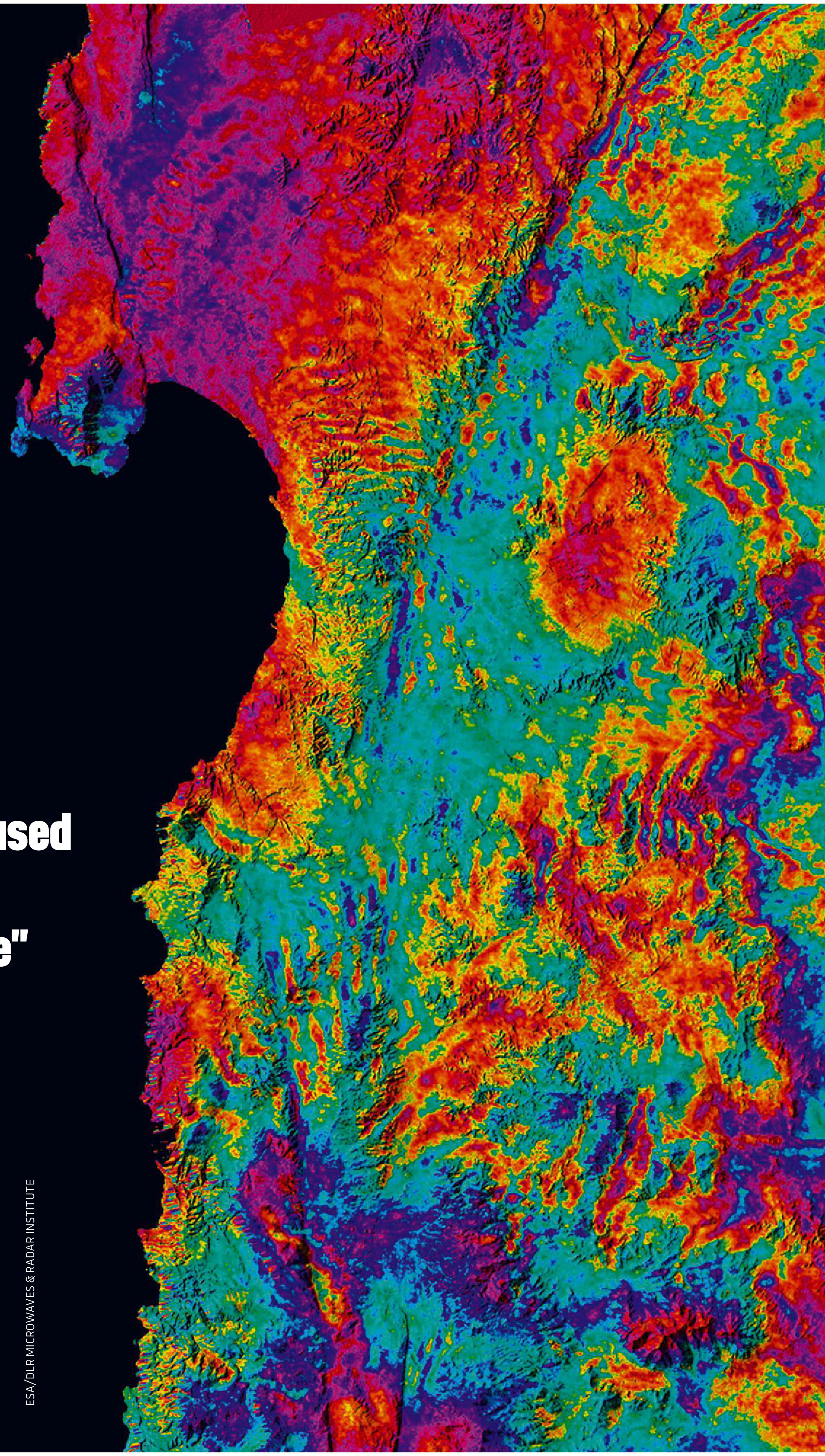
It was taken by the European Space Agency's (ESA) Copernicus Sentinel-1C satellite, which launched in December 2024. Using radar, the satellite can map Earth's surface down to the millimetre, whatever the weather. To do this, it takes two or more images of the same location on different days to record both the amplitude and phase information (the strength and location) of the radar pulse that's reflected back.

"The satellite will be used to map subsidence, glacier flow and more"

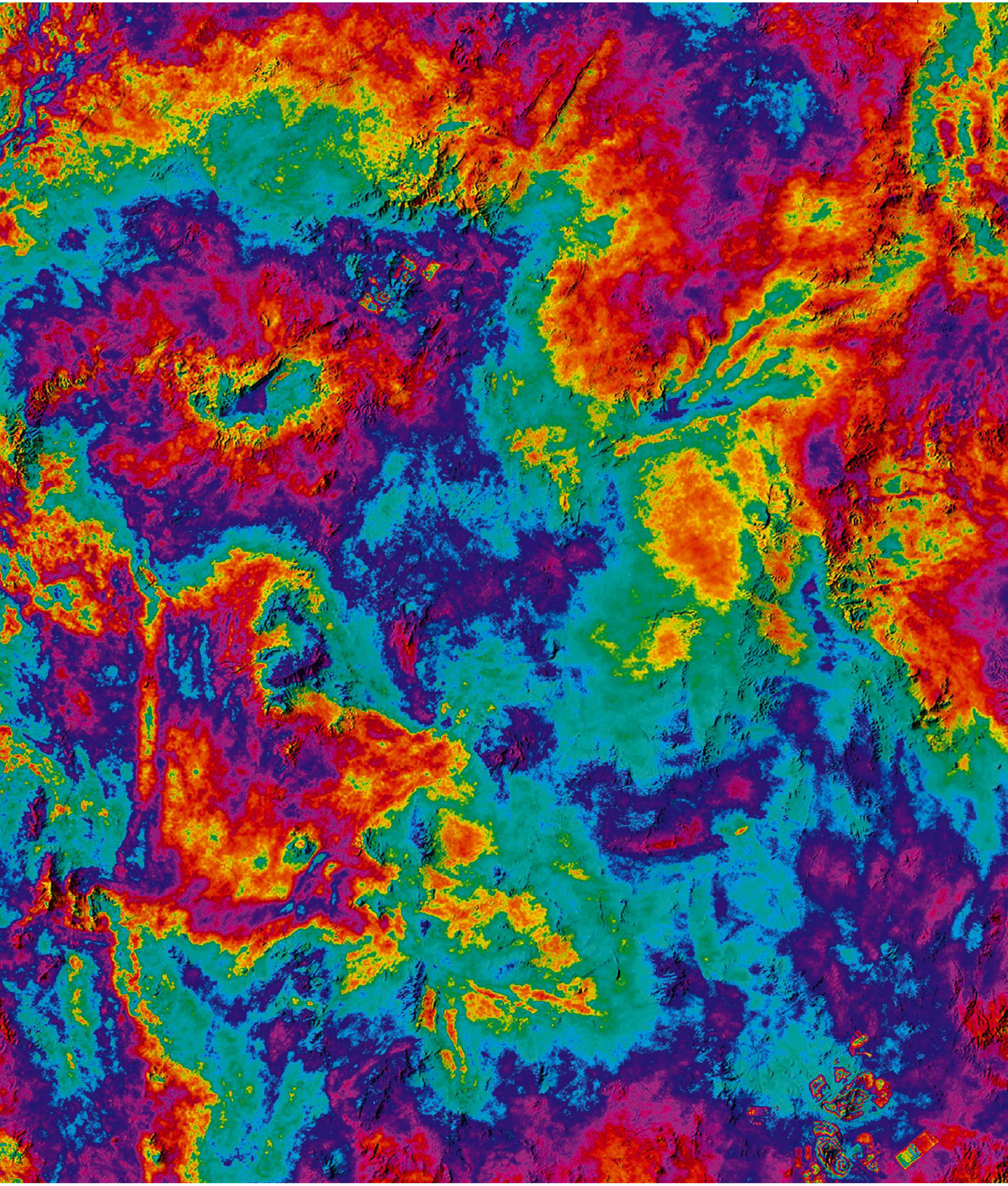
On 20 January and 1 February, Sentinel-1C captured the data that made this image of northern Chile, where the Atacama Desert meets the Pacific Ocean. In the bottom right of the image, the Zaldívar copper mine can be seen (the dark shapes are the pits).

The satellite will be used to map subsidence and glacier flow, as well as natural disasters like landslides and earthquakes. It's also primed to become an important part of marine surveillance, detecting oil spills and illegal fishing.

"We're thrilled with these first interferograms," ESA's Sentinel-1 Project Manager, Ramón Torres, said. "Quality is never an accident."



ESA/DLR MICROWAVES & RADAR INSTITUTE



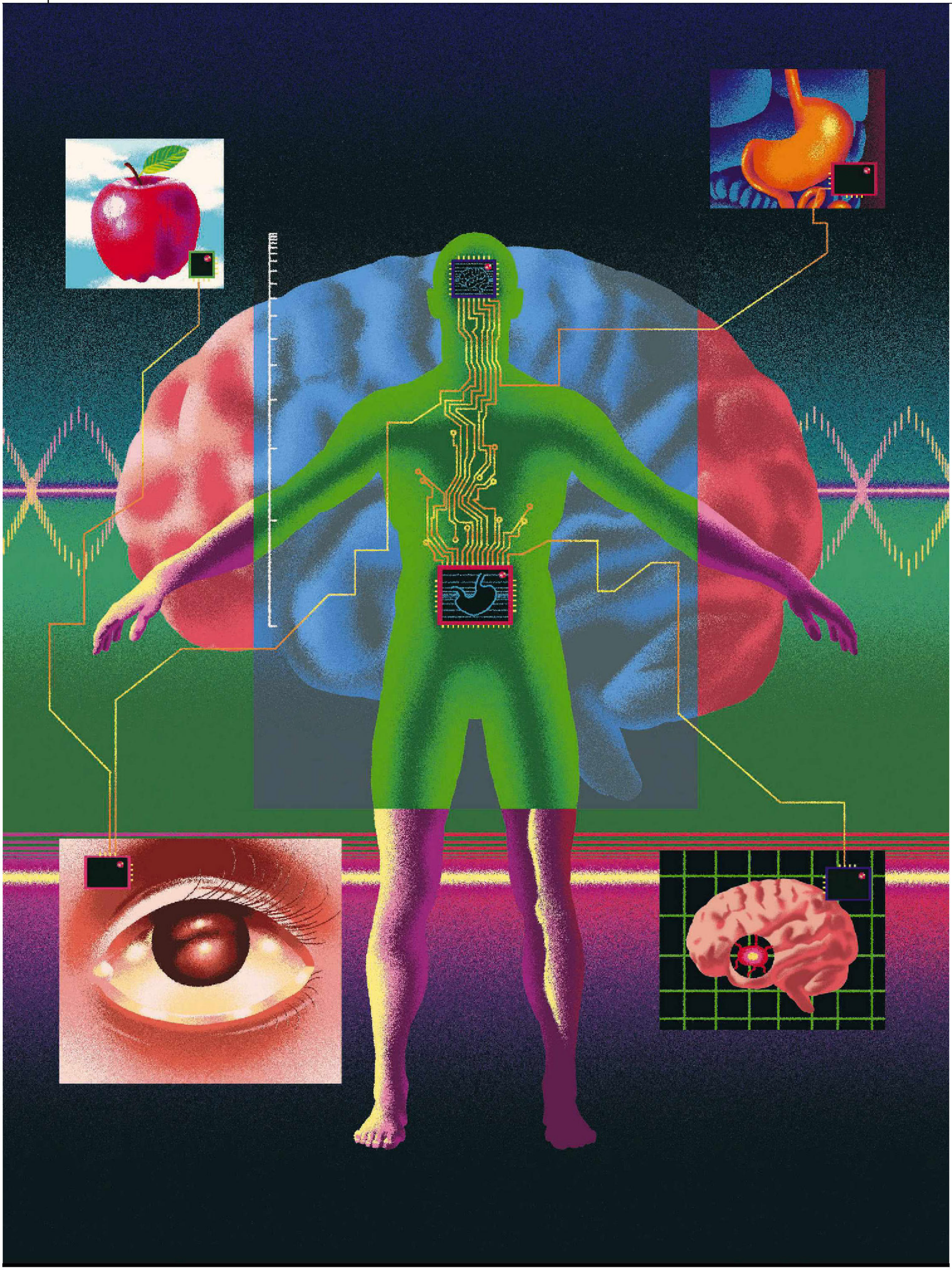


ILLUSTRATION: BERNARD LEONARDO

COMMENT

The map that may lead to a new obesity treatment

A better understanding of the pathways in the human hypothalamus has huge possibilities for medicine

I have been working in the field of obesity for nearly 30 years, largely trying to understand bodyweight regulation through genetics. And what I know is that the genetics of bodyweight is, by definition, the genetics of how the brain influences our appetite.

Broadly speaking, your brain needs to know two things to influence appetite. First, it needs to know how much fat you're carrying (as your long-term energy source, it's directly related to how long you would last without food). Second, it needs to know how much you're eating and have just eaten (these short-term energy signals are going to come from your gut).

These long-term fat and short-term gut signals come in the form of hormones secreted into your bloodstream. When they reach your brain, it senses them and influences your next interaction with a refrigerator, restaurant menu or supermarket.

> "The hypothalamus isn't just a fuel sensor, it plays a role in a myriad of fundamental biological functions"

The key area of the brain that acts as a 'fuel sensor' for these signals is the hypothalamus. Roughly the size of your thumbnail and the shape of an almond, it sits at the base of the middle of your brain.

Understanding the neuronal circuits that control appetite is another matter, though. It's near-impossible (not to mention ethically dubious) to get into the brain of a living person, so what we know largely comes from animal models, primarily mice. But as good a model as mice are, they're not humans.

With many current drugs targeting the hypothalamus (including the latest class of anti-obesity and diabetes drugs, such as Ozempic), enhancing our understanding of its human-specific architecture is crucial. Brain banks containing appropriate donor samples have been around for a while, but it's only over the past few years that several important technologies have matured sufficiently to make mapping the human brain possible.

The first is called 'single-cell transcriptomics': the sequencing of all RNA from an individual cell. RNA acts as the messenger between DNA and protein, transcribing DNA information and translating it into proteins that perform pretty much all of the biological functions of your body.

Since DNA is the same in every cell, single-cell DNA sequencing doesn't give us any useful information. What's more, it's far too difficult to identify all the proteins produced from a single cell. Sequencing the entire repertoire of RNA from a single cell, or transcriptomics, however, is easy to do. It's relatively affordable and, crucially, produces a fingerprint that identifies the role of that cell.

The second technique is 'spatial transcriptomics', which is when the transcriptomic process is performed on super-thin slices of tissue. Each slice is just 10 microns thick (1 micron is 1/1,000th of a millimetre), meaning we can get more than 1,500 slices from an entire hypothalamus. If you consider single-cell data like an alphabetical index of towns and cities, then spatial transcriptomics places the individual cells onto a specific spot on a map. The problem is that this approach is still prohibitively expensive.

So, instead, a team I'm part of took a sampling of slices and combined this with the single-cell data. This allowed us to construct, for the first time, a spatial-cellular map of the human hypothalamus.

We call it HypoMap. We published it in the journal *Nature* in February 2025 and have made the entire map publicly available for researchers worldwide.

With our trusty new map, we began to explore appetite pathways. We started with the pro-opiomelanocortin (POMC) neurons, a major player in the fat-sensing neurocircuit, which, when genetically disrupted, results in obesity in humans, mice and labrador retrievers. POMC neurons also act as a convergence point for sensing the key gut signal, GLP1, the hormone upon which drugs like Ozempic are based.

When we compared POMC neurons between humans and mice, we found significant disparities in the expression levels of GLP1 receptors. Since we've been relying on mice for our models, this carries direct implications for current obesity treatments.

Yet this barely scratches the surface of possibilities with HypoMap. The hypothalamus isn't just a fuel sensor, it plays a role in coordinating a myriad of fundamental biological functions, such as maintaining body temperature, sleep and thirst, as well as regulating sexual and parental behaviour, responses to stress and circadian rhythms.

We hope that making HypoMap openly accessible will help us illuminate neuronal populations and circuits more broadly and identify new treatments for a range of conditions linked to the hypothalamus.

PROF GILES YEO

Giles is a geneticist at the University of Cambridge, whose work focuses on food intake, genetics and obesity. He's also a presenter on the BBC show Trust Me, I'm a Doctor.

ILLUSTRATION: OLENA SHMAHALO

COMMENT

The simple recipe for making powerful astrophysical jets

You need just three ingredients to make these truly colossal 'double-sided lightsabers'

On paper, the two most spectacular astronomical discoveries of the last few weeks couldn't possibly have less in common.

One is an image captured by the James Webb Space Telescope of a newborn star in our Galaxy, the Milky Way, about 450 light-years away. It's an amazing picture of the birth of a solar system in a thin disc of dust in which planets are, as we speak, slowly starting to form.

The other is a combination of optical and radio data showing us a giant astrophysical system, larger than the Milky Way, and so far away that its light has taken more than 12 billion years to reach us. It gives us a glimpse of the incredible, intergalactic violence wrought by a supermassive black hole actively devouring its surroundings.

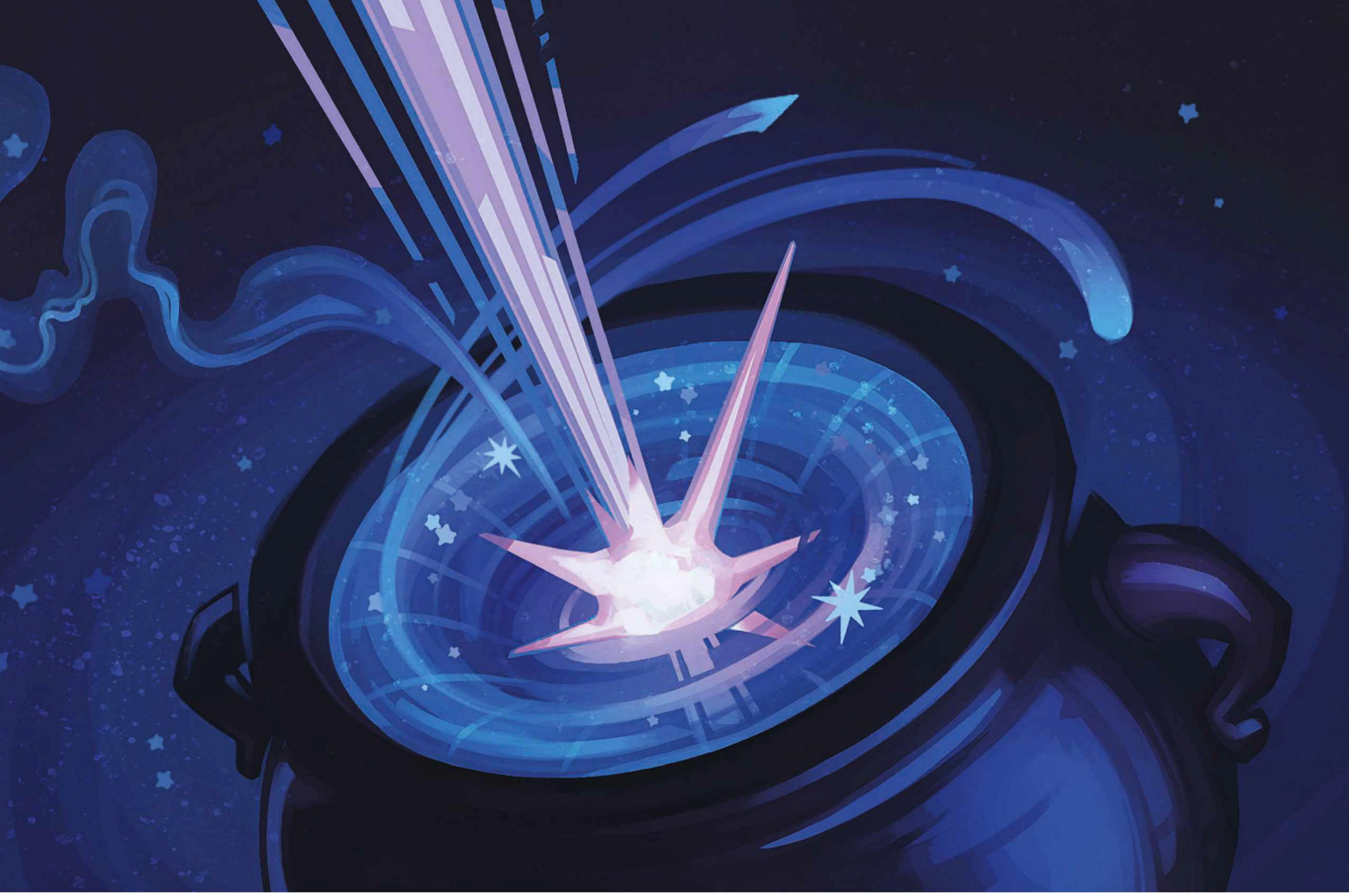
Still, a glance at the images shows a striking similarity, challenging any sense of scale. Both objects seem to be shooting light or material out into space in long, straight jets, stretching far out into the distance, like double-sided lightsabers.

Astrophysical jets are extremely common in the Universe and while the details vary, the physics that drive them are all based on the same basic features: gravity, rotation and magnetic fields.

The first thing you have to know is why so many things in space make discs. There are the spiral-armed, disc-shaped galaxies (like the Milky Way we live in); there are the proto-planetary discs that coalesce into planets orbiting more or less in a flat plane; and there are accretion discs, where gas and dust swirl into black holes and other massive objects with disc-y whirlpools around them.

In all these cases, the formation of a disc happens in a few simple steps. First, gravity attracts material toward an object from all directions. You might think that would be the end of the story and it would just fall right in, but since everything in space is moving all the time, the chance that the path is an absolute straight shot is very small. Generally, the material has some momentum to one side or another and falls in an arc, possibly settling into an orbit around the object.

But when there's a lot of falling material – bits of gas and dust, all on different trajectories – it tends to get knocked around en route. If two specks of dust are coming from the same direction, they'll start to orbit together, but if they're coming from opposite sides, they'll crash into each other, lose



"Those magnetic fields can form complicated shapes, but often it's a kind of puffy doughnut on the disc's plane"

momentum and fall toward the centre. Over time, this means that whatever the average rotation of the collapsing cloud was in the beginning, the whole thing will flatten out to a rotating disc in the same direction.

So gravity and rotation can account for all the discs. But how do jets happen? This is where magnetic fields come into the picture.

Magnetic fields are pretty much everywhere in the cosmos. They show up inside stars and planets due to the movement of the stuff inside them (like the fluid metal around Earth's inner core or the roiling plasma inside the Sun), they trace through the spiral arms of galaxies and can even be found in intergalactic space. Magnetic fields are produced whenever charged particles are moving and there are a lot of charged particles in space, because collisions and radiation can ionise otherwise neutral atoms, separating them into charged particles.

When gas and dust collect in discs, magnetic fields tend to be along for the ride. Those magnetic fields can form complicated shapes, but often it's a kind of puffy doughnut on the disc's plane with long streamers of magnetic field lines stretching out vertically at the poles. When material swirls in along the disc, pulled in by gravity, some of those charged particles get caught up in the long, straight polar fields and spiral outward along them into space, forming a jet. How strong and narrow that jet is depends on the magnetic field and rotation that launches it.

In the case of a protostar, the jet can be bright, but with such a small amount of material and a relatively weak magnetic field, it tends not to extend much beyond the disc in the plane. A supermassive black hole at the centre of a galaxy, on the other hand, can launch jets that stretch hundreds of thousands, or even millions, of light-years into space. In that case, the supermassive black hole is providing a powerful engine for the jet: the extreme gravity pulls material into the disc, and the black hole's spin can tighten the existing magnetic field and launch the particles out with tremendous strength.

We see astrophysical jets elsewhere, too, like in stellar-mass black holes devouring their orbiting companion stars, and rapidly rotating pulsars beaming lighthouse flashes across the cosmos. It's best not to get too close to the source of the beams, but from a distance, jets can give us spectacular – and beautiful – insights into the gravitational and magnetic engines powering the most extreme wonders of the cosmos.

DR KATIE MACK

(@AstroKatie) Katie is a theoretical astrophysicist. She currently holds the position of Hawking Chair in Cosmology and Science Communication at the Perimeter Institute for Theoretical Physics.

COMMENT

We can learn valuable lessons from the 'polar bear capital of the world'

As the climate crisis pushes humans and animals closer together, it's crucial that we coexist with kindness

Polar bears are "not encroaching on Churchill," insisted artist Sandra Cook when I visited her home studio. "This is the polar bears' land." Given that fewer than 1,000 people live year-round in Churchill, on the edge of the Canadian Arctic, there are approximately as many polar bears as there are humans.

The remote community in Manitoba sits on a spot where the river meets the Hudson Bay. It's here that, for thousands of years, bears have gathered at the start of winter, waiting for the first ice to form. However, as the Arctic continues to rapidly warm, each year the bears have to wait longer on land.

Cook has seen bear footprints in her backyard – "right where I walk every morning. That was terrifying." Her teenage daughter, Kara, has been rushed indoors during breaks at school, because a polar bear was spotted approaching. This is part of everyday life in the so-called 'polar bear capital of the world'.

The story of human/polar bear coexistence in a changing Arctic climate is what brought me to Churchill late last year. With its local population of bears, known as the Western Hudson Bay polar bears (or "blubber-hunting ice bears" as Alyssa McCall from Polar Bears International describes them), climate change puts the remote town in a uniquely difficult position.

Regardless of name, the bears need the sea ice on the bay. It's their marine hunting platform, from which they pounce on the calorie-rich seals needed to power their huge bodies through the extreme cold. When the bay thaws in the summer, the bears move back onto the land. An increasingly early thaw and delayed freeze means that every year these polar bears spend about a month longer on shore than they did in the 1980s, according to research led by the US Geological Survey.

VICTORIA GILL

Victoria is BBC News's award-winning science correspondent. Her reporting can be found on television, radio and online.

> "Every year, these polar bears spend about a month longer on shore than they did in the 1980s"

Now, between five per cent and upwards of 50 per cent of the bear population enjoy an extended summer on land, which vastly increases the likelihood of encounters with humans. The town of Churchill responds not by shooting bears (although that does, rarely and unfortunately, happen), but by following guidelines about how to avoid them. A specialist task force operated by Manitoba Conservation – the Polar Bear Alert Program – patrols the town 24/7. Any bears persistently hanging around are caught in humane traps and moved further along the coast, a safe distance away from people.

This is an intensive and relatively expensive operation. But it works. The last person to be killed by a bear in Churchill was a homeless man named Thomas Mutanen, who died in 1983 in the earliest days of the task force.

Today, attacks are extremely rare. Meanwhile, an estimated 10,000 tourists visit the town every year to see the wild bears out on the tundra.

Researchers use this opportunity to test tracking devices and deterrents that aim to make it easier to keep people and bears apart. One system currently being tested is called 'bear-dar': an AI-powered, radar-based detection system set up on the ice to be 'trained' to spot bears day and night.

The Churchillians I spoke to are neither fearful nor resentful about living alongside the bears; they are respectful and practical. "We need a mind shift," Cook told me. "As a society, we seem to have this disconnect with nature. And we're all part of it."

But not everyone shares that attitude. A common response when wildlife poses a threat to safety or livelihoods is to turn the offending species into an enemy. Here in the UK, reintroduced sea eagles, now thriving around the Isle of Mull, are being blamed for the loss of prized livestock on some farms. The rebounding of the grey wolf population in Europe has led to calls in favour of culling.

Language in local media reports is often combative. A group of orcas off the coast of Portugal and Spain were described as deliberately "attacking" boats rather than "playing" with them, which is what marine mammal experts have largely concluded.

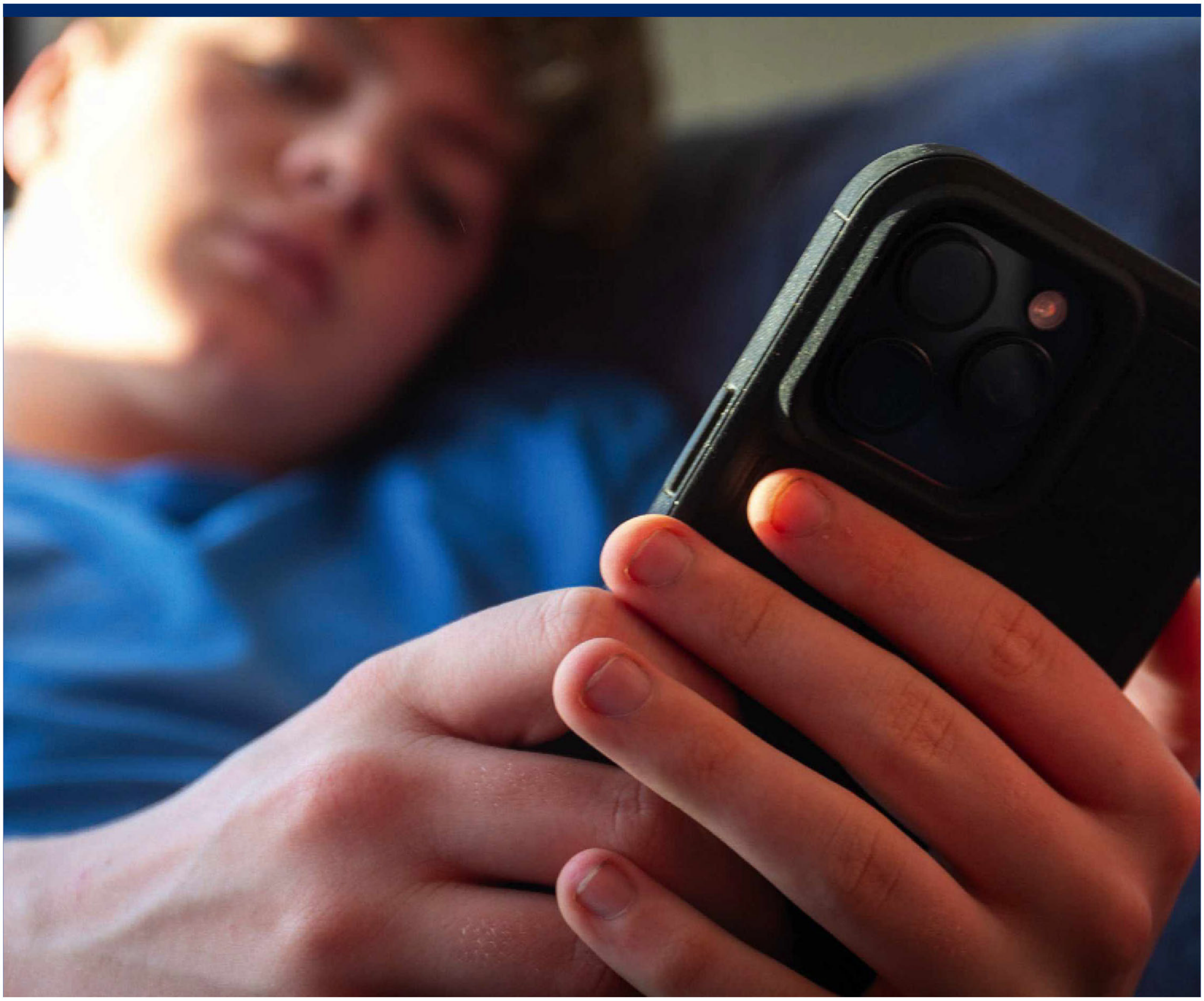
While the story in Churchill wasn't always one of peaceful coexistence, the community has worked hard to understand the bears' behaviour. "Gone are the days when bears are shot," the town's mayor Mike Spence told me. "We want to make sure that's in the past."

If 900 residents can live with the understanding that magnificent, dangerous predators are on their doorstep, I hope it can inspire the rest of us too.

ILLUSTRATION: SIMBIE YAU

REALITY CHECK

THE SCIENCE BEHIND THE HEADLINES



REVIEW

'Brain rot': is TikTok causing brain abnormalities?

A new study seems to prove what we've all suspected: bingeing on short-form videos is bad for our brains. But not all experts are convinced...

BBC

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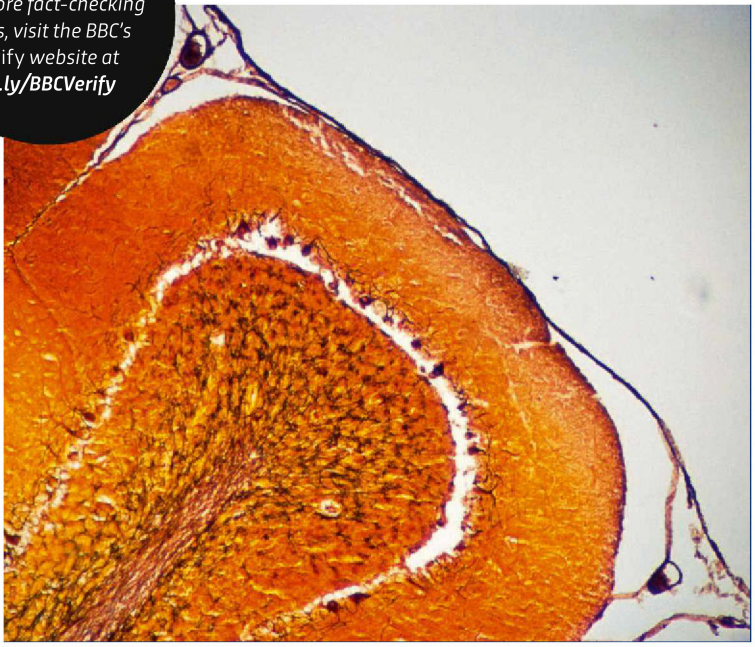


ABOVE A section of the cerebellum in a human brain, which researchers suggest can be altered by too much TikTok

LEFT Scrolling through endless short videos may be a bad habit, but whether it causes 'brain rot' is harder to confirm

Named as the Oxford Word of the Year for 2024, 'brain rot' is defined as the "supposed deterioration of a person's mental or intellectual state" as a result of watching too much "trivial or unchallenging" content online, such as TikTok or Instagram Reels. The term is often bandied around in a jokey fashion, but what if there's a grain of truth to it?

That's the seemingly alarming implication of a new study, published by a large team of brain scientists based at Tianjin Normal University in China.

WHAT DID THE STUDY FIND?

The researchers scanned the brains of 111 students, aged between 17 and 30, all regular consumers of the short videos on platforms like TikTok. Participants were asked to complete a questionnaire about their habits of watching short-form online content, which included indicating how much they agreed with statements such as "My life would feel empty without short videos" and "Not being able to watch short videos would be as painful as losing a friend".

> **"Envy might make someone more likely to head to TikTok"**

Intriguingly, researchers found that those who felt the most attached to short videos had noticeable differences in their brain structure. These participants had more grey matter in their orbitofrontal cortex (OFC), a region near the front of the brain involved in decision-making and emotional regulation. Similarly, they had more grey matter in their cerebellum, the small, cauliflower-shaped part at the back of the brain that plays a role in movement and emotions.

The conclusion: this was indeed bad news for lovers of TikTok, Instagram Reels et al. Having an oversized OFC could be a sign of what the researchers described as "heightened sensitivity to the rewards and stimuli associated with short-video content". They speculated that spending hours scrolling through videos might have led to this neural bloating.

The team also suggested that a beefed-up cerebellum might help the brain process short video content more efficiently, as an unintended result of frequent binge-watching. This could create a reinforcing cycle, where the more content a person watches the stronger these brain pathways become, which makes the habit even more ingrained.

But that's not all. The researchers went on to perform a second scan to track the participants' brain activity while they rested with their eyes closed. They found a greater synchronisation of activity within multiple areas of the brain. This included the dorsolateral prefrontal cortex (a region involved in self-control); the posterior cingulate cortex (an area that plays a role in thinking about yourself), the thalamus (a relay station for brain signals) and the cerebellum.

These functional brain differences could reflect a range of problems among the more addicted participants, according to the study. Issues might include having trouble disengaging from videos and a tendency for excessive social comparison while watching them.

The participants were asked to complete another questionnaire about 'dispositional envy', a factor measured by how much they agreed with statements such as "I strive to reach other people's superior achievements". The team found that many of the links between short-video addiction and differences in the brain were also tied to higher levels of envy. This suggests that envy might make someone more likely to head to TikTok (or that spending lots of time on TikTok might make that person feel greater envy) and over time this habit could lead to potentially harmful changes in the brain.

SO, DOES TIKTOK CAUSE BRAIN ROT?

For the avid consumers of short online videos out there – or maybe concerned parents – the idea that watching habits might be reshaping our brains is understandably disconcerting. Yet this study must be placed in a wider historical context in which new technologies and media have always provoked exaggerated neurological claims. Also, there are the profound limitations of the research to consider.

It's nearly 20 years since *The Atlantic* magazine ran a cover feature that asked "Is Google making us stupid?" and the claimed answer, in a nutshell, was "Yes". The author, Nicholas Carr, lamented that he used to be a →

GETTY IMAGES X2

“The study was entirely cross-sectional... There was no before-and-after comparison to show cause and effect”

→ “scuba diver in the sea of words”, but now, thanks to Google, he zips “along the surface like a guy on a jet ski”. In the same era, countless brain-imaging studies of questionable quality were published, many purporting to show the calamitous effects of the World Wide Web on our fragile minds.

A few years later, neuroscientist Prof Baroness Susan Greenfield launched a media campaign arguing that “mind change” – the impact of digital technologies, the internet and video games on the brain – was as serious a threat to humanity as climate change. She even wrote a dystopian novel about the web’s dehumanising effects. It received mixed reviews: one critic questioned whether it was one of the worst science-fiction books ever written.

Today, we’re doing okay-ish – I don’t think our brains have turned to mush. But of course, these earlier scares were before the advent of TikTok. Perhaps there’s something uniquely damaging about the kind of short, scrollable, nonsensical content available.

I asked Prof Peter Etchells of Bath Spa University, an expert on the psychological effects of digital technologies, if this was plausible. “To the best of my knowledge, there isn’t any good science to support the idea that short videos are specifically or uniquely bad in terms of effects on the brain,” was his response.

Could this new brain study be that good science? I’m inclined to say that the evidence suggests otherwise.

WHAT DID THE STUDY GET WRONG?

Let’s take a look at some limitations of the study. If the goal were to prove that watching hours of TikTok harms the brain, a more effective approach would be to scan participants’ brains before and after they consumed different amounts of the supposedly harmful content. Yet the study was cross-sectional, meaning it only captured a single snapshot in time. There was no before-and-after comparison to show cause and effect.

“[From this study] you can’t say anything about whether watching short videos causes changes in the brain, or whether certain types of brain structure precede certain types of video consumption,” says Etchells. “This study doesn’t really add anything useful to our understanding of how digital technologies impact us.”

The researchers’ made a speculative leap by claiming that short videos might have caused the brain changes they observed, but even beyond that there are still several things to consider.

First, they searched the entire brain for differences that correlated with scores on the video addiction scale. This approach is a common issue in brain-imaging research, since it increases the risk of finding false positives. In other words, the more comparisons you make, the more likely you are to stumble upon random differences that appear significant, but are actually just coincidences.

Second, even if we do accept that the observed brain differences are real and caused by watching TikTok, interpreting them involves a great deal of speculation. The study framed increased synchronisation in the brain – known as regional homogeneity (ReHo) – as being a negative effect. But, ReHo is neither inherently good nor bad. In fact, other studies have linked increased ReHo in certain brain regions to positive outcomes, such as those observed in meditation training.

Perhaps the study’s biggest flaw is its reliance on a dubious questionnaire-based measure of short-video addiction, which lacks strong scientific validity. As Etchells says: “Short-video addiction is essentially an invented term and isn’t a formalised, diagnosable clinical disorder.”

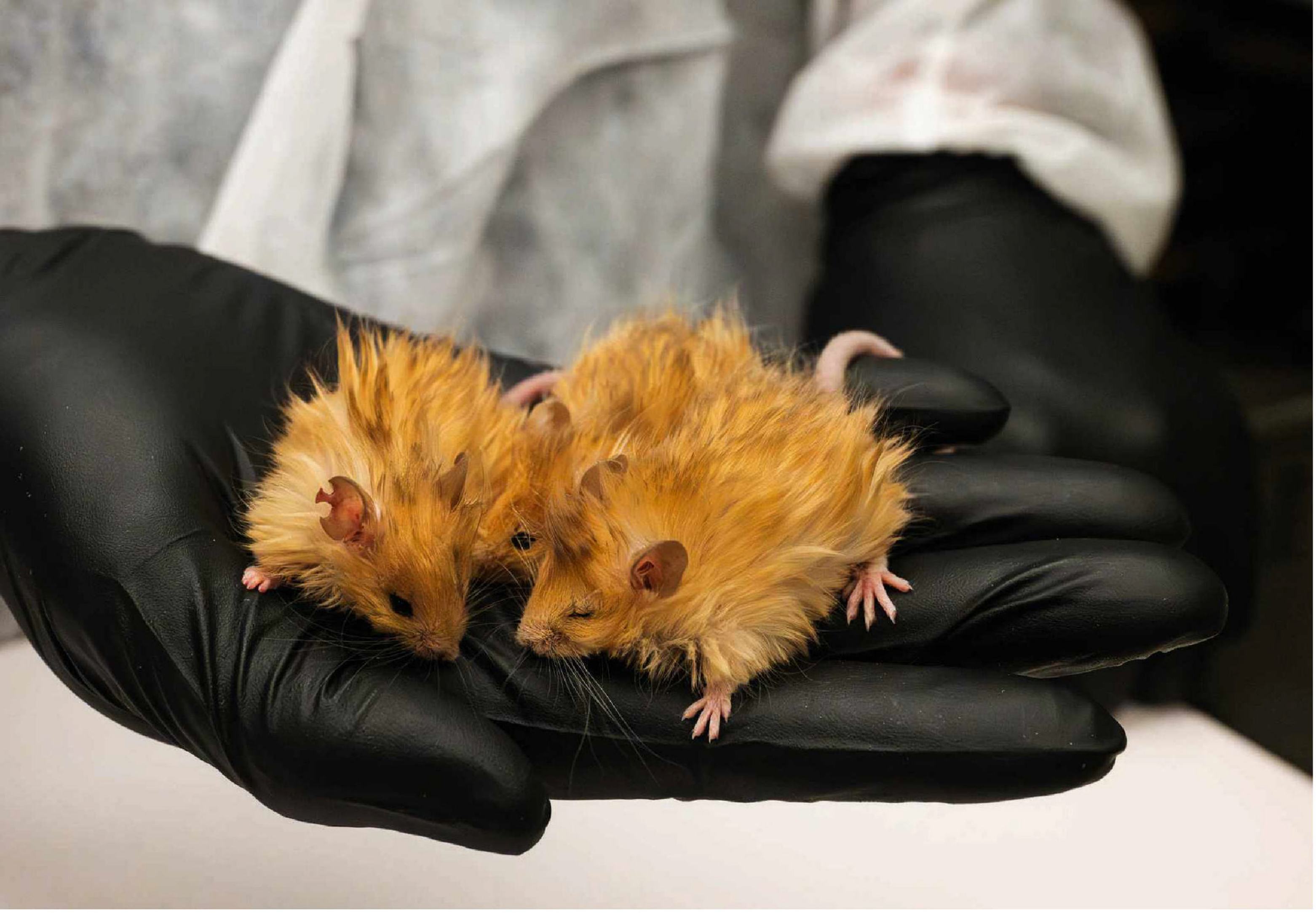
Taken together, these issues suggest we shouldn’t be overly concerned that TikTok is radically reshaping young people’s brains in harmful ways. Yes, excessive time watching frivolous videos can still be problematic, but it’s more productive to focus on developing healthier media habits rather than worrying about brain changes or addiction.

“Often, when we see studies like this hit the news, it’s a good opportunity to pause and reflect on whether we’re happy with our tech use,” says Etchells. “It’s worth thinking about what you can do to weed out the things you’re unhappy with, while appreciating that we get lots of benefits from these technologies."

BELOW Prof Baroness Susan Greenfield has warned of the dangers of digital technologies to the human brain

ALAMY

by **DR CHRISTIAN JARRETT**
Christian is a cognitive neuroscientist, science writer and author.



COLOSSAL LABORATORIES & BIOSCIENCES

ABOVE The 'woolly mice' mark an important turning point in the debate for biotechnology

COMMENT

Is creating a 'woolly mammoth mouse' a step too far for biotechnology?

Are scientists so preoccupied with whether or not they could bring back mammoths, that they're not concerned with whether they should?

Colossal Biosciences, a US biotech start-up, has announced the birth of what it calls a "woolly mouse" – the world's first animal genetically altered to express key genes from a woolly mammoth. The company says the luxuriously haired rodents are living proof that it's making progress in its mission to resurrect the woolly mammoth from extinction within a matter of years.

To make the mice, scientists used the latest genetic technologies to introduce eight simultaneous edits to the genomes of laboratory mice. These include the addition of genes that cause its fur to grow up to three times longer than normal, and others that make the hairs wavy and golden. Other edits targeted genes associated with fat metabolism that are thought to have helped mammoths increase in size.

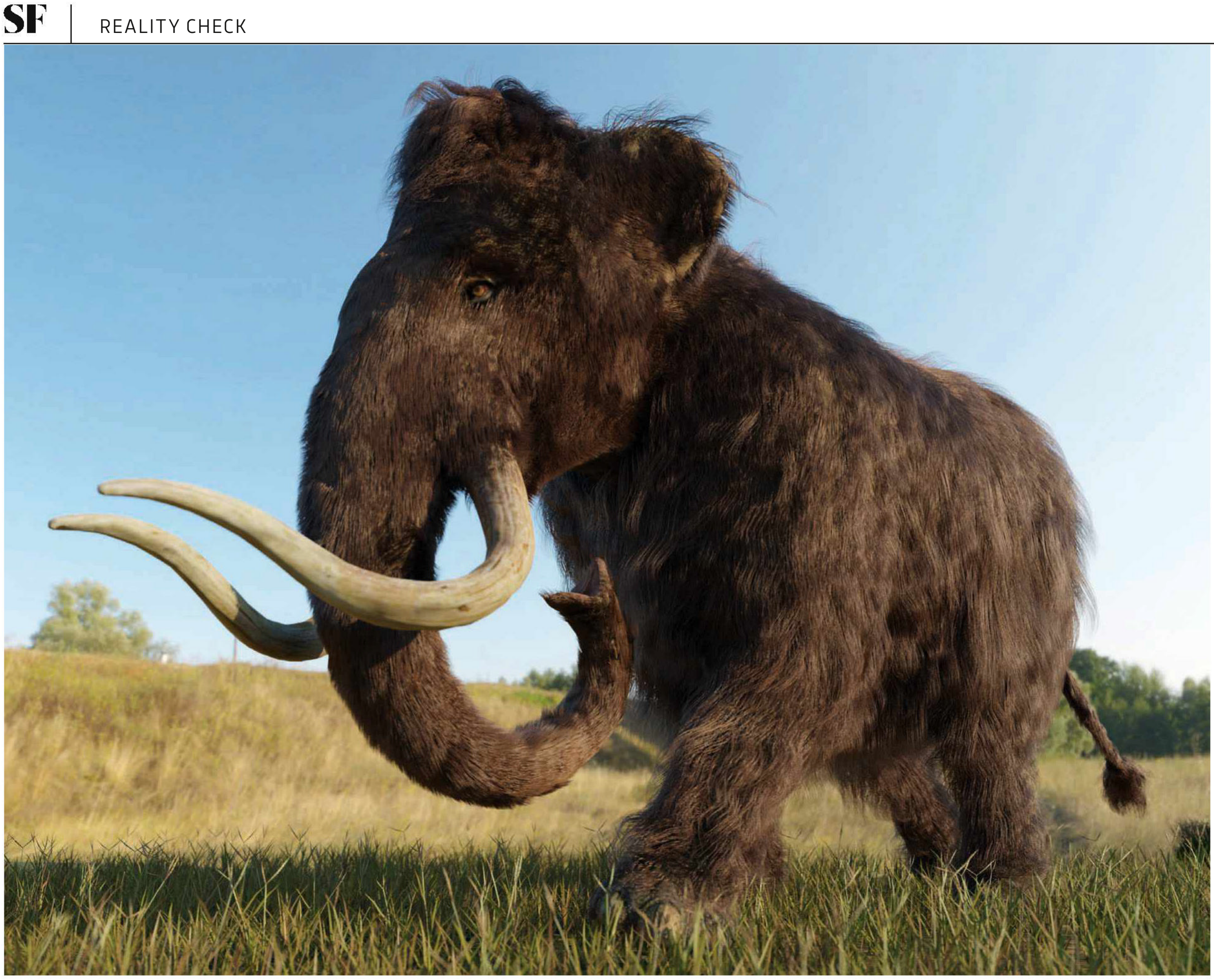
The mice are the result of years of painstaking work by scientists to reconstruct key parts of the mammoth genome. The last woolly mammoths are thought to have died around 3,000 years ago, and scientists have been piecing together bits of degraded mammoth DNA from remains between 3,500 and 1.2 million years old. This is the first time that some of the key genes identified through that work have been expressed in a living animal.

MAMMOTH 2.0

Colossal's ambitious long-term plan is to add lots of these mammoth genes to embryos of modern-day elephants to create mammoth-like hybrids.

Despite its claims to be resurrecting the woolly mammoth, the original *Mammuthus primigenius*, with all its original genetic complexity and population diversity, isn't being brought back to life. The creatures are more accurately described as "cold-resistant elephants".

Announcements that the return of the mammoth is close have been made repeatedly by various groups, →



LEFT Mammoths went extinct around 1650 BC, but still share 99.6 per cent of their DNA with today's Asian elephants

ABOVE RIGHT The dodo went extinct in the 1600s

BELOW RIGHT The last thylacine, or Tasmanian tiger, died in captivity in 1933

→ dating as far back as 2011. The groups are generally privately funded and the exact details of their work are often rather opaque.

But these living, breathing and rather cute woolly mice do show that scientists have made impressive progress in reconstructing some of the key genes that made mammoths unique. Colossal's chief scientist Dr Beth Shapiro says the mice are "an important step toward validating our approach to resurrecting traits that have been lost to extinction."

A MAMMOTH TASK

There's still an awful lot of work to do before we see mammoth-like creatures stepping out across the tundra or walking around our zoos.

For a start, it's much easier to create gene-edited mice than elephants. Mice have been a staple of genetic experiments for decades and can be bred in huge numbers, quickly. Elephants, on the other hand, are rarely used in laboratory experiments and happen to have the longest gestation period of any living mammal – over 18 months.

Colossal has been making impressive progress in manipulating elephant cells into stem cells that could, one day, be used to create modified embryos.

But even if Colossal can create viable elephant-mammoth embryos, both Asian and African elephants are endangered, so can't be used as surrogate mothers in any great numbers, if at all.

This means Colossal must also develop its own artificial wombs to develop the experimental embryos all the way to birth. This has never been done before: not only will such a system have to recreate all the complexities of a placenta, it'll need to support a calf that weighs at least as much as an Asian elephant calf – that's over 100kg (220lbs).

But perhaps the biggest question that remains is simply, why? Colossal says that resurrecting the mammoth – and other similar work to resurrect the dodo and thylacine – will lead to biotechnology that can help save other species from environmental change. The company argues that starting with these iconic extinct creatures will inspire interest and investment like nothing else could.

> "Shouldn't we focus our efforts on saving habitats and ecosystems, not individual species?"

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It's certainly true that the project generates lots of media attention, and has attracted over $200m dollars (£157m) of investment that probably wouldn't have come to conventional conservation projects.

And there are examples already of this technology being used to help species facing extinction today. In Australia, for instance, gene-editing is being used to give Northern quolls – adorable and endangered marsupials – resistance to the poison of the cane toad, an invasive species that's killing many animals in the region.

In the US, scientists have used similar biotechnology to boost the genetic diversity of black-footed ferrets, which had been reduced to such a tiny population size that they were essentially becoming inbred.

More broadly, Colossal's work could help scientists produce eggs, sperm and embryos for a range of threatened species, including Asian and African elephants, to help boost their numbers.

THE COULD WE/SHOULD WE QUESTION

But do these lofty ambitions justify the *Jurassic Park*-esque use of genetic engineering? Many people feel uneasy about the modification, let alone a complete overhaul, of genomes, especially in intelligent, social animals like elephants.

And what will life be like for the first man-made woolly elephants? Where will they live, and will they be introduced to a herd or family? Will they be healthy or dogged by genetic problems? And shouldn't we focus our efforts on saving habitats and ecosystems, not individual species?

In recent years, genetic engineering has gained greater acceptance among the public, and is generally seen as an important way of producing things like new medicines or disease-resistant crops. Could the creation of a big, hairy elephant be the thing that makes people feel biotechnology has gone too far? Or, as Colossal hopes, might it serve as an inspiring symbol of how technology can save the thousands of species that become endangered each year?

It's a question that biologists, ethicists and biotech regulators need to consider carefully, as work on scaling up from mouse to mammoth continues. **SF**

by **TOM IRELAND**

Tom is a freelance science journalist, and editor of The Biologist, *the bi-monthly magazine of the Royal Society of Biology.*

INNOVATIONS

PREPARE YOURSELF FOR TOMORROW

GOING DEEP

An advanced new research station is being developed to explore the potential for a human settlement under the ocean

Whether it's to escape environmental collapse or to explore new, unknown territories, the drive to establish human colonies in places other than on Earth has been gaining momentum in recent years. And while proposed bases on the Moon or Mars might get all the headlines, there's another equally hostile and largely unknown location a lot closer to home that explorers are also looking towards: the bottom of the ocean.

This is by no means a new idea. Starting with French oceanographer Jacques Cousteau in the 1960s, people have been building and spending limited amounts of time in underwater habitats for decades. More recently, NASA has been sending people to the Aquarius Reef Base, a research facility on the ocean floor just off the coast of Florida, since 2001. Located 20m (approx 65ft) below the surface, scientists, engineers and prospective astronauts typically spend 7–14 days in the module.

New technology is making the prospect of longer-duration stays underwater possible, though, and British company, Deep, is employing it to develop habitats specifically for that purpose. The tech may be up to the task, but the real question is, are we?

ABOVE THE ATMOSPHERE, BELOW THE SEA

Humans are relatively weak. We don't do well without oxygen or sunlight, and we're not big fans of major changes in pressure. In other words, we're not necessarily the best candidates for life at the bottom of the sea.

That's not to say we're incapable of living in hostile environments. Since the year 2000, astronauts have lived for extended periods aboard the International Space Station (ISS), a habitat assembled in conditions that are just as challenging as those we would experience underwater. Various astronauts have clocked up over 300 consecutive days aboard the ISS, but cosmonaut Valeri Polyakov holds the record with the 437 days he spent aboard Russia's Mir space station between 1994 and 1995.

The thing is, astronauts who've spent long periods in space often arrive back on Earth with a variety of health concerns, including reduced bone density and muscle atrophy. But what about the prospects for people looking to live underwater?

The longest case study is Rudiger Koch, a German aerospace engineer who spent 120 days living in a capsule (the top of which is pictured below) submerged 11m (36ft) beneath the surface of the Caribbean Sea between 2024 and 2025. Koch reported no health concerns when he emerged and celebrated with champagne and a cigar.

GETTY IMAGES

In second place is Prof Joseph Dituri. He spent 100 days in a lodge at the bottom of a 9m-deep (30ft) lagoon in Florida, in an effort to understand the physical and psychological health effects of underwater life.

Dituri performed daily tests on himself both while submerged and after returning to the surface. And, other than a new-found height, he wasn't just fine, he was *better*. He noticed improvements in his sleep, cholesterol levels and inflammation levels. His stem cell count increased, as did his testosterone and performance on cognitive tests. In fact, Dituri emerged with a biological age (a measure of how well your body is ageing) 10 years younger than his chronological one. He was, however, a little over 1cm (about 0.5in) shorter, as the pressurised environment inside the lodge had caused him to shrink.

A STEP TOWARDS LIFE UNDERWATER

With such a small bank of evidence, we don't have a solid grasp on what the prospects might be for people looking to spend extended periods underwater. That's where Deep comes in. The ocean technology and exploration company is developing two habitats to find out and has set the ambitious goal of having a permanent presence beneath the ocean by 2027. The company has even taken over a flooded quarry in Gloucestershire to use as a test bed for its underwater habitats.

Deep is working on two habitats: the Vanguard, a smaller module for three people on short-term stays under the sea; and the Sentinel (pictured opposite), a 16m (52ft) capsule that they hope will serve as a longer-term habitat – complete with living spaces, bedrooms and research facilities – and can house researchers at depths of up to 200m (656ft) for 28 days at a time.

The goal is to allow researchers to spend longer living underwater and enable them study the ocean floor as well as the effects of living underwater. But getting people to these depths is challenging.

"The risky part for a diver is going down and coming back up," says Dr Dawn Kernagis, director of scientific research at Deep. "They're breathing compressed gas and the pressure is changing, increasing the risk of decompression sickness (DCS), where bubbles can form in the blood."

Though most cases of DCS (commonly known as 'the bends') are mild, the most severe can affect the brain, spinal cord, the respiratory system and the circulatory system.

To minimise the risk of it occurring, Deep aims to keep researchers staying in the Sentinel 'saturated' – a state where the body has absorbed all of the dissolved gases it would at a particular pressure. Essentially, this is the body reaching a new underwater equilibrium.

"Saturation tanks, like the ones we're building, allow divers to go to these lower depths and stay there much longer because they can adjust to the pressure. This takes their time [at these depths] from hours to a month or so," says Kernagis.

Deep plans to closely monitor researchers at Sentinel during their stay to better understand the long-term physical and psychological ramifications of deep-sea living. These stays will lay the groundwork for progressively longer ones, from weeks, to months, and maybe even years. And who knows, in the not-too-distant future, some of us could find ourselves living in a modern Atlantis.

FIVE OF THE BEST NOISE-CANCELLING HEADPHONES

The outside world is noisy. But you can stop it from interfering with your choice of tunes with a good pair of noise-cancelling headphones. Here's our pick of the top five...

...The best for a little bit of everything

Nothing is a fairly new brand in the tech world, launching back in 2020, but it's even newer to the earbud market. With its first earbuds arriving in late 2021, Nothing lacks the back catalogue that its competitors in this round-up have. Nevertheless, it's a real contender, with the right blend of affordability, features and sound quality.

There are three options to choose from in Nothing's range, but it's the Ear (a) earbuds that offer the best overall balance. These funky offerings look like the younger, cooler sibling of Apple's AirPods. Despite the lower price point, the Ear (a) buds provide ample noise cancelling. In our test, they even managed to block out a full train of rowdy rugby fans, which is surely the biggest testament to their abilities. Sound quality is also great, offering bass-pumping sound that performs well for almost all types of music.

Overall, Nothing's Ear (a) buds are a bit of a jack-of-all-trades. They're by no means the absolute best for sound quality, noise cancellation or other features, but they do everything very well, without forcing you to pay a fortune.

Nothing Ear (a)
Nothing.tech, £99

...The best for in-ear fans

Over-the-ear headphones aren't for everybody. If you prefer something more discreet, Sony's WF-1000XM5 are among the best earbuds out there.

This comes down to a few factors, but what you need to know is they sound great, block out plenty of noise and have a comfortable, lightweight design. They also come with a range of tips to suit ears of all sizes, from extra small to large. Use the correct fit and a seal is formed that, even without the assistance of noise-cancelling, blocks out most surrounding noise.

Switch the noise cancelling on and Sony's earbuds perform exceptionally well. Like their similarly priced competitors, the noise-cancelling function adjusts how much noise is blocked depending on your surroundings.

While they aren't the most attractive-looking earbuds, they more than make up for that with their audio quality: they sound incredible. Though that shouldn't come as a surprise, Sony has been dominating the market in recent years thanks to their audio tech.

Sony WF-1000XM5
Sony.co.uk, £219.99

...The best for style and sound

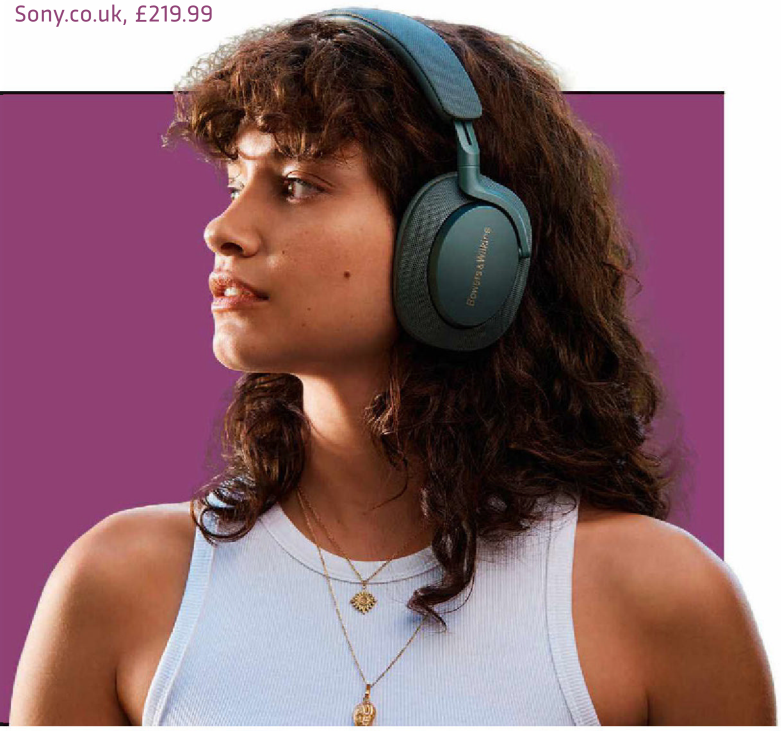
The Bowers and Wilkins Px7 S2e headphones are great all-rounders, but at £300 they're quite comfortably in the expensive bracket.

That said, they're more affordable than headphones from some of the other leading brands and offer similar quality. They have a premium feel and they sound great, especially for those who prefer their music unaltered – these headphones avoid boosted bass and aggressive mixing.

The noise cancelling doesn't measure up, however. We had to really crank up the volume to avoid a lot of unwanted external noise interfering with our music.

Another, albeit minor, complaint: they don't fold. If you're not wearing the Px7 S2e around your neck or over your ears, they become a pain to carry. Small complaints for a pair of headphones that sound and look this good at this price point.

Bowers and Wilkins Px7 S2e
Bowerswilkins.com, £299



...The best for budgeting bargain hunters

Of course, you can get great noise cancellation when you splash the cash, but what about if your budget doesn't stretch that far? The Soundcore Space One comes in at just £89.99 without compromising on features. Owned by the tech giant Anker, Soundcore specialises in the affordable end of audio.

You get a surprising amount of noise cancellation for the price. There's also a companion app that allows you to customise your sound experience and toggle between using full noise cancellation and none. In busy places, like cafés or train carriages, the full noise cancellation blocks out surrounding sounds effectively, with only the occasional louder noise making its way through.

With a foldable design and an impressive 40-hour battery life, these headphones would be ideal for a daily commute or extended bout of travelling.

Soundcore Space One
Soundcore.com, £89.99

...The best for overall noise-cancellation

There are plenty of noise-cancelling headphones out there, but Bose's offerings are consistently among the best. The QuietComfort Ultras continue the trend. They have padded ear cups that effectively seal off noise even before they're powered up, but it's the highly customisable noise cancelling where they really shine.

Using a feature called Bose Aware Mode, the noise cancelling adjusts automatically to match the external volume and even adapts to account for random louder noises. In our tests, the Ultras exceeded expectations in every scenario, wrapping us in blissful silence on trains, in cafés and even while walking past noisy construction sites.

They come with a steep price tag, however, which will keep them out of reach (and earshot) for many people.

Bose QuietComfort Ultra
Bose.co.uk, £449.95

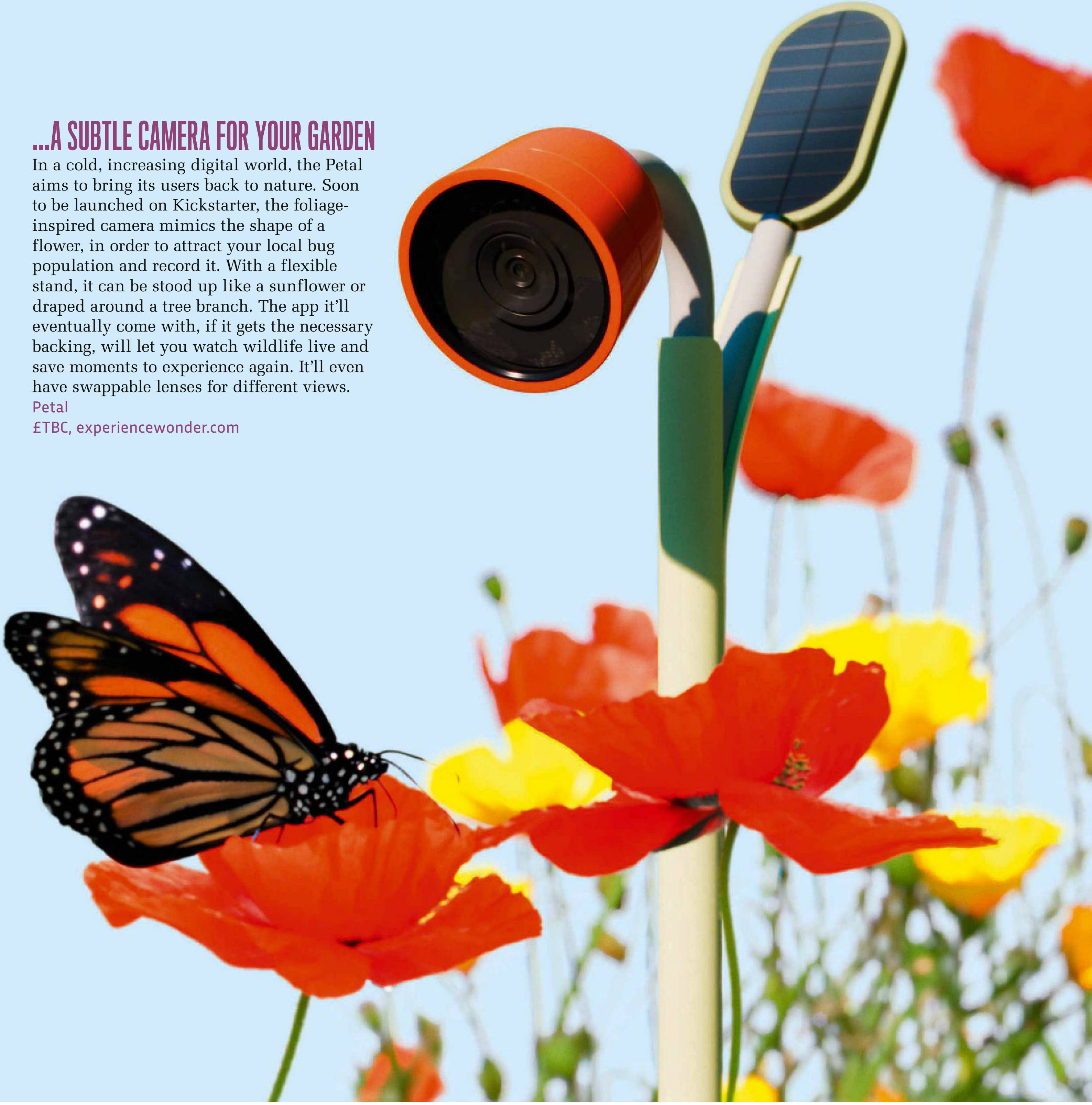
IDEAS WE LIKE…

Our pick of the month's smartest tech

…A SUBTLE CAMERA FOR YOUR GARDEN

In a cold, increasing digital world, the Petal aims to bring its users back to nature. Soon to be launched on Kickstarter, the foliage-inspired camera mimics the shape of a flower, in order to attract your local bug population and record it. With a flexible stand, it can be stood up like a sunflower or draped around a tree branch. The app it'll eventually come with, if it gets the necessary backing, will let you watch wildlife live and save moments to experience again. It'll even have swappable lenses for different views.

Petal
£TBC, experiencewonder.com



↑…A COMPLETELY WIRELESS TV

We don't often see real innovation in the TV market, maybe a rollable screen here or a transparent display there. Useful changes are rare, but the Displace TV brings a whole raft of them. Claiming to be the world's first wireless TV, Displace relies on a built-in long-life battery and TV streaming system. It also requires no screws or mounts – powerful suction pads on its back means it can be easily attached to a wall or taken down, making it renter-friendly. But here's the kicker – prices start at $2,499 (and it's only available in the US for now).

Displace TV
$2,499 (approx £2,020), displace.TV

↓…A SMART CHARGING SYSTEM YOUR PHONE

The Swippitt is for people who don't have the patience to charge their phones and can afford to do something about it. It's a charging system that consists of two parts: the 'Hub', a toaster-like charging station for five batteries; and the 'Link', a case for your smartphone that uses one of the Hub's batteries to power your phone. When your phone runs out of juice, you slot it into the Hub and it swaps the Link's empty battery for a fully charged one. The battery-swapping process takes seconds so you can get back to swiping and scrolling in no time.

Swippitt Instant Power System
$450 (approx £360), swippitt.com

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↑…A PORTABLE PIZZA OVEN

Gozney makes some of the best pizza ovens on the market. The problem is that its products are massive in both size and price. Its latest venture intends to buck that trend. Though the Tread will still set you back £499.99, it's sized for easy portability. Made using a "hyper-rugged" aluminium and steel construction, the oven is lightweight and durable. All you need is a gas source and you can cook wood-fired pizzas anywhere. And it won't take long – Gozney claims the Tread can be up to cooking temp in 15 minutes.

Gozney Tread
£499.99, gozney.com

↓…A LAPTOP WITH A ROLLABLE SCREEN

In the race to make the best laptop, it no longer seems to be a question of who has the most power, the brightest display or the quickest processor. No, the fight is to have the strangest gimmick. But we have to admit that with the new ThinkBook Plus Gen 6 Rollable, the gimmick is actually quite useful: a second screen built into your laptop. It offers the functionality of two displays without the annoyance of having to carry a monitor around with you. The perfect blend of useful and weird.

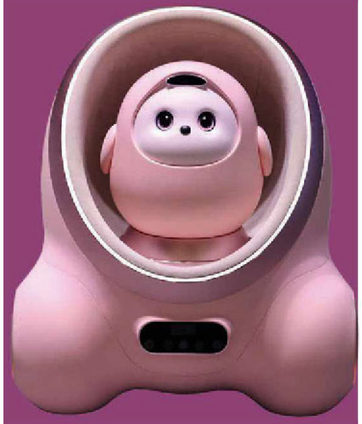
ThinkBook Plus
Gen 6 Rollable
£TBC, Lenovo.com

IDEAS WE DON'T LIKE…

…A VARIATION ON THE FLYING CAR

The Xpeng Aeroht is one of the weirdest car gimmicks we've seen. Just a concept for now, it's a futuristic-looking six-wheel electric minivan (think a beefed-up Cybertruck). The real surprise is in the boot, however, where a personal six-rotor aircraft is kept. In theory, you'd be able to push a button and the aircraft will unfold out of the back, ready for take off. Your futuristic-looking van will even charge up the aircraft as you drive around, so you're ready for all those moments when you need to take to the skies.

Xpeng Aeroht X5
£TBC, aeroht.com



…A CREEPY ROBOT FOR YOUR CHILD

Who needs a babysitter when you've got a creepy robot to look after your child? TCL's AI-Me (pronounced Amy), is a friendly-looking robot that sits in a wheeled pod. It rolls around filming and interacting with your children using its childlike voice and expressive eyes. It all sounds nice, in theory: it reads stories and acts as a playmate. But there's something a bit dystopian about a robot rolling around after your child intent on forging an emotional connection, however much you can customise it with furry onsies.

TCL AI-Me
£TBC, TCL.com

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A HITCHHIKER'S GUIDE TO THE QUANTUM WORLD

Quantum physics is confusing. Really confusing. You just won't believe how vastly, hugely, mindbogglingly confusing it is. Fortunately, scientists have been exploring it for years now and are, finally, beginning to make some sense of it all by PHILIP BALL

In the same way that "space is big" (as described in Douglas Adams's *The Hitchhiker's Guide to the Galaxy*), quantum physics is confounding.

Science's best minds have been puzzling away at it for over a century, pawing at the subject like Schrödinger's cat playing with a ball of cosmic string. But the bafflement is beginning to give way to understanding and we're starting to get a grasp on not only what quantum physics could mean, but what uses it could be put to.

Here are just a few suggestions for entries in what could be an early draft of a hitchhiker's guide to the quantum world. Just remember: don't panic!

QUANTUM INTERNET

Entangled encryption and a quantum cloud could change how we share data

In the 1980s, researchers pointed out something intriguing: the laws of quantum physics should permit information that has been encoded in quantum objects – like photons, the 'quantum particles' of light – to be sent from one person to another in a totally secure way. By connecting the transmitted particles via a phenomenon called quantum entanglement, it would be impossible for some would-be eavesdropper to intercept and read the message without the recipient detecting such tampering.

This quantum cryptography was later demonstrated for light signals sent through the air or down optical fibres, and in 2007 the technique was used for secure transmission of the results of a Swiss election. Quantum cryptography has now been carried out for messages sent from China to Austria via signals bounced off a special quantum-enabled telecommunications satellite.

Now, there are plans afoot for a 'quantum internet' in which all messages are sent via fibre or satellite with secure encoding. Last year, researchers in China sent quantum-encrypted information through optical fibres between a sender and receiver more than 12km (7.5 miles) apart in an urban area. This was the first step in creating a national quantum-information grid.

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QUANTUM COMPUTERS

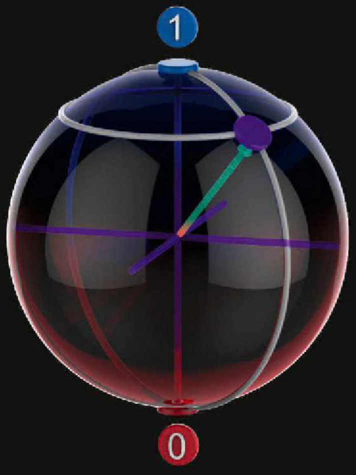
The challenges of making a sci-fi staple a reality

Quantum computers have been a godsend to science-fiction writers in need of a machine capable of doing anything, even creating alternative realities. In truth, quantum computers have nothing like that power. Yes, today's prototypes have achieved impressive things, like performing calculations that would take conventional computers longer than the age of the Universe to complete. But these amount to party tricks: quantum computers remain some way off from tackling the most challenging of tasks, like predicting new drugs and materials or simulating the weather.

The issues lie in the immense engineering obstacles. Whereas conventional computers encode information in binary form as 1s and 0s, a quantum 'bit', or qubit, can be placed in states that are a mix of 1 and 0 (the purple spot on the qubit illustrated below). To carry out a computation, qubits must be entangled, meaning that their settings are interdependent. Sustaining an entangled state among hundreds – or even thousands – of qubits is technically hard and generally requires very low temperatures.

What's more, we have to develop ways to protect quantum computers against random errors that can occur if the state of a qubit gets flipped accidentally. With conventional computers, we can keep back-up copies of the bits, but the laws of quantum physics prohibit that for qubits.

"Error correction places a huge resource overhead on quantum computing", says Prof Anthony Laing, a physicist at the University of Bristol. In fact, current quantum computers are concerned as much with correcting errors as with running the tasks. Yet error correction methods are steadily improving and Laing says that if researchers can make components more resistant to errors, quantum computers could become radically simpler and more powerful.



QUANTUM SENSORS

High-precision measurements will have a host of applications

Although quantum information technologies (such as computers and cryptography) tend to steal the limelight, other technologies that rely on quantum rules have been around for some time. Lasers, invented in the 1960s, exploit a quantum effect discovered by Albert Einstein in 1917.

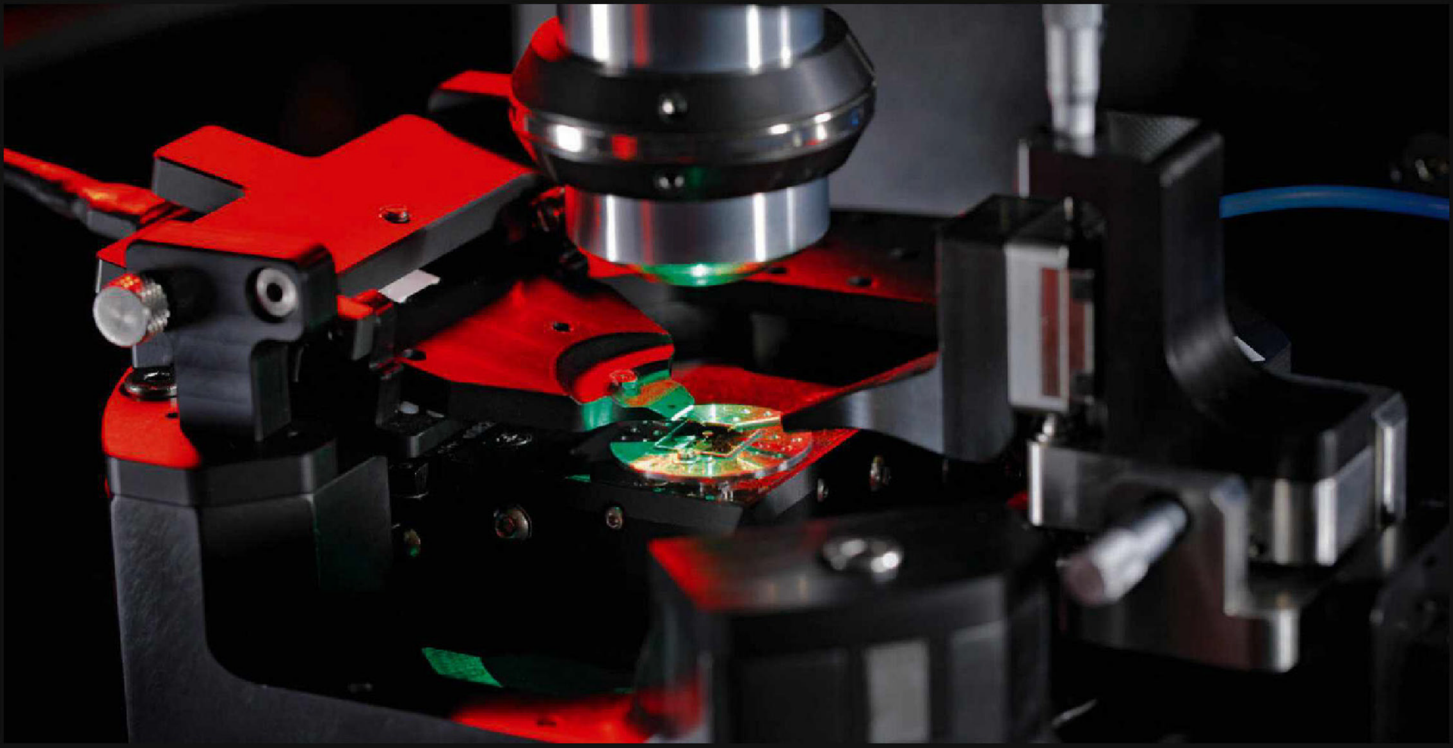
Many of the newer quantum technologies are sensors that exploit quantum effects to attain far greater accuracy than classical devices can provide. For example, electrons in atoms are forced by quantum physics to have very particular energies, each with an associated frequency. In atomic clocks we can use that frequency like the steady pulse of a pendulum, which never deviates since it's fixed not by the limits of engineering precision, but by the laws of nature. And by clever use of entanglement between atoms, even the apparent quantum limits on how accurately we can measure such a pulse can be cheated. Such highly accurate timekeeping already has applications, such as for GPS navigation.

Meanwhile, quantum magnetometers use a property called 'spin' in individual quantum particles, such as atoms embedded in crystals, to create sensors for detecting very weak magnetic fields. The fields change the spin state of the particle and this change can be detected from a shift in how the particle absorbs light. A quantum magnetometer (like the one pictured below) can be used in medicine – in brain scanning, for example – and in geological prospecting and more.

What's more, the fact that quantum particles can act like waves opens up opportunities for making extremely precise measurements of distance and movement. Such 'matter waves' can get out of step with one another if they're sent along different paths, meaning that they will interfere when brought back together. This is similar to how light waves interfere to cancel out some colours and enhance others when reflected from iridescent surfaces. By exploiting this effect, even tiny differences in path or motion become detectable.

Quantum interference is already being used in devices for measuring gravitational fields by letting clouds of cold atoms fall along different trajectories before bringing them together again. But the principle might also be used to measure acceleration for navigation systems and motion trackers. It could even test the fundamental theories of physics.

> **"QUANTUM MAGNETOMETERS USE A PROPERTY CALLED 'SPIN' IN INDIVIDUAL QUANTUM PARTICLES TO DETECT VERY WEAK MAGNETIC FIELDS"**



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QUANTUM ENTANGLEMENT

The mindboggling web that could alter our reality

Quantum entanglement is arguably the strangest feature of quantum physics. This is the phenomenon whereby particles can seem to affect one another instantly, no matter how far apart they are. To put it another way, it's as though some properties of particles are 'nonlocal', meaning they're not confined to the particle itself.

As such, quantum entanglement seems to ignore conventional notions of space. It's as if two entangled particles simply don't notice that they're separated and behave as parts of a single quantum object.

What, though, if quantum particles aren't really objects located in space at all, but form an entangled web of interacting entities, and what we think of as space *emerges* from that web? It sounds odd, but some theoretical physicists have shown one mathematical description of a special kind of space to be equivalent to what the 'shadow' of a web of entangled particles looks like when projected onto their boundary. Imagine the entangled web as a room full of objects and space is the dappled shadows they throw onto the walls.

The basic idea is that entanglement weaves quantum objects together into what looks like ordinary space, so that the distance between them is really a measure of how entangled they are. If we can find ways to test this speculative idea, it could transform our notion of what reality is fundamentally composed of.

QUANTUM THERMO-DYNAMICS

How entanglement can be harnessed to boost energy efficiency

Thermodynamics is, in essence, the science of how efficiently machines can be made to work. Developed in the 19th century during the Industrial Revolution, it's all a matter of how well an energy source (such as coal) can be used to do work (like pumping water), given that some energy is always lost as heat.

But that doesn't take entanglement into account. Scientists now realise that the usual limits on efficiency imposed by the laws of thermodynamics might be beaten in 'quantum engines', where the component parts, which might be individual atoms, are entangled. Think of it like the improvements in efficiency that can come from having two people coordinating their actions rather than working independently.

Ultra-efficient quantum heat engines have already been demonstrated, in which the switching of atoms between quantum states can, like a steam-powered piston, be harnessed to do work. The same idea can be inverted to make quantum refrigerators. Then there are quantum batteries (an illustration of one is pictured below). With energy stored in the quantum states of atoms, these can charge more quickly and discharge more efficiently if operated in arrays of entangled copies. All these devices are microscopic, but could be useful for powering and cooling microelectronic devices on silicon chips.

QUANTUM GRAVITY

Does quantum mechanics fit with General Relativity?

Despite quantum mechanics passing every experimental test that scientists have set for it, not everyone thinks it'll be the final word. That's because it doesn't seem to fit with the other foundational theory of physics: General Relativity, devised by Einstein to describe gravity.

According to the theory of General Relativity, space and time are smooth and continuous, whereas in quantum mechanics there's a kind of fundamental granularity to it all. Usually this doesn't matter, because quantum mechanics tends to be used for very small things, such as atoms, while General Relativity is used for very big things, like stars or the entire Universe. Still, having two theories that don't dovetail doesn't seem right.

"The quantum nature of gravity is an absolute necessity, without which the laws of nature as we know them would crumble", says Prof Claudia de Rham, a theoretical physicist at Imperial College London.

Finding a quantum theory of gravity is therefore "the biggest challenge of modern physics", according to Dr Igor Pikovski, a physicist at the Stevens Institute of Technology in New Jersey, in the US. We know that three of the four fundamental forces of nature obey quantum theory, "but we don't know if that's true for gravity," he says. "All attempts to 'quantise' Einstein's theory of gravity have so far not produced a satisfactory answer."

To that end, physicists need experiments that at least hint at what such a theory should look like. If gravity is a quantum force, then there must be a particle that 'carries' it, which physicists call the graviton. Pikovski's group and others hope to find it. "Such experiments were thought to be impossible, but this was wrong," he says. "I can imagine these experiments will materialise within a few years or a decade. It's an exciting time."

There may be another option, according to de Rham. That's to look not at the very tiny, but the very big; at the "signature of the quantum nature of gravity in the sky". Random quantum fluctuations in spacetime in the earliest moments of the Universe, when it was still tiny, should remain imprinted in features of the cosmic microwave background radiation that pervades all of space. According to de Rham, astronomers are trying to observe this quantum fingerprint across the Universe.

THE QUANTUM MEASUREMENT PROBLEM

It has been the biggest mystery in quantum theory since the beginning

It's been a hundred years since quantum mechanics was devised, yet there's still no agreement about what it actually means. The reason for this division comes down to one key issue: measurement.

Typically, if we want to know a certain property of an object – say, the speed of a tennis ball – we simply observe and measure it. If we're careful enough, we can work out the speed accurately while ensuring that the act of measuring doesn't affect the ball. In quantum mechanics, however, it seems that a measurement fundamentally changes the nature of a quantum object and what we see depends on how we look at it. So, if we observe an atom with one method, it might look like a tiny particle with a particular position in space. Look at it another way, though, and it's a spread-out wave.

The basic problem is that quantum mechanics doesn't specify what a measurement is. All it can do is tell us the probabilities of seeing the various possible outcomes – for instance, how likely the electron is to be here or there. So how do we go from all those possible positions before the measurement, to a single location after it? And can the mere act of looking really induce that change?

One of the founders of quantum theory, Niels Bohr, famously argued with Albert Einstein (seen sitting next to Bohr in the picture below left) about that question. Einstein felt sure there had to be something we could meaningfully say about a quantum object before it's observed, but Bohr said that quantum theory is silent about that. The root of the debate was what we can consider to be real at all.

With no one able to see how to resolve the dispute, the issue went ignored for decades. It's only been since the 1970s that it became possible to carry out experiments. The results seem to exclude Einstein's view of a well-defined single reality, regardless of whether we observe it or not. That doesn't mean Bohr was right, though.

There are now many other interpretations of quantum theory vying for the crown. One insists that particles are real and can take crazy paths guided by waves in a pervasive quantum field. Another argues that all possible outcomes of a measurement are realised, but in different worlds that split off from each other when the observation is made.

While there's still no sign of any agreement, it at least no longer seems impossible to imagine that one day experiments will sift through the options and tell us what reality is really like. SF

by **PHILIP BALL**

Philip is a science writer and a former editor of Nature. *He's the author of* Beyond Weird: Why Everything You Thought You Knew About Quantum Physics is… Different. *His latest book is* How Life Works: A User's Guide to the New Biology *(Picador, £22).*

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Richard broadcasts the benefits of **TURMERIC+**

Regular physical activity is one of the best ways to reduce stress and anxiety and raise self-esteem. This was certainly the case for Richard Hamilton, 56, BBC World Service broadcaster and author.

Staying active and enjoying the outdoors has always been important to Richard, but a discomfort in his foot was holding him back and it started to affect his mood.

'I've always liked to exercise but I was unable to do the things I enjoyed, like cycling to work, going to the gym and running,' he says. 'In truth, I found it a little depressing and felt quite down in the dumps.'

'Then I noticed an advertisement for Turmeric+ and liked the science behind it. I didn't know whether it would help me but I thought I'd give it a try.'

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BEHIND DEATH'S DOOR

They leave their bodies, witness a bright light and return forever changed. But do survivors of near-death experiences truly glimpse the great beyond? New research into the brain's final moments could decode these visions at life's edge

Words by **DR CHRISTIAN JARRETT**
Illustrations by **LE.BLUE**

I'll never forget the day the neuropsychiatrist Dr Peter Fenwick visited my undergraduate psychology class in the 1990s. Tall and dapper with a refined voice and neuroanatomical terms tripping from his lips, Fenwick conveyed old-school authority.

One of the subjects he lectured us about was so-called near-death experiences. Originally a sceptic, he said there was now compelling evidence that many people close to death were able to recall seeing themselves from above. Even more astonishing, some described witnessing events in distant parts of the hospital – things they couldn't have seen unless their consciousness had somehow separated from their physical bodies. Something about his erudite, understated delivery sent shivers down my spine.

Plenty more research has since explored near-death experiences (NDEs) – episodes of bodily disconnection, spiritual revelation, and intense emotions reported by those who come close to death and survive. Turns out they could be incredibly common: one recent survey reported that 15 per cent of patients in intensive care had experienced a NDE.

NDEs are by no means a new phenomenon, however. The scholar Dr Gregory Shushan has collected accounts of NDEs through time and across cultures, finding numerous examples, from 7th-century BC China to 19th-century Ghana. Hieronymus Bosch's 16th-century painting *Ascent of the Blessed* is widely considered a visual portrayal of a NDE.

The concept first really came to prominence in the 19th century when the Swiss geologist Prof Albert von St Gallen Heim collected stories from fellow climbers who nearly died. The US psychologist Dr Raymond Moody then popularised NDEs with his 1975 book *Life After Life*, which Fenwick dismissed at the time as "psychobabble" before encounters with NDE-ers changed his mind. →

→In other words, there are plenty of documented NDE cases. And many continue to baffle scientists and raise perplexing questions about the nature of consciousness and life itself.

Should we believe them all? My reaction has always been scepticism tinged with wonder. It's hard to listen to accounts of people who've had these experiences and not be moved.

For instance, Leanda Pringle from Connecticut had a NDE a little over 15 years ago, brought about by a double kidney infection. She experienced floating above her body and felt a sense of being everywhere and nowhere at the same time.

"I've no idea how long I was floating in that abyss before I began to feel a presence," she recalls to me. "As it got closer I began to feel immense bliss. It was beyond anything I had ever felt before in my life. It's very hard to put that feeling into words. It was as if I was intertwined with it, but at the same time it felt as if it was hugging me."

Tommy McDowell, a retired army veteran from Texas, spent seven days on a ventilator after suffering multiple organ failure induced by sepsis. During that time, he had a NDE that involved feeling a powerful sense of goodness.

"It was a transformational presence of peace, comfort, serenity, love and home," he says. "I was no longer confused. I was no longer alone." He also saw a cloud of crystallised light that invited him towards it. As he entered, "I could feel embedded trauma, regret and loss washing away from my back and shoulders."

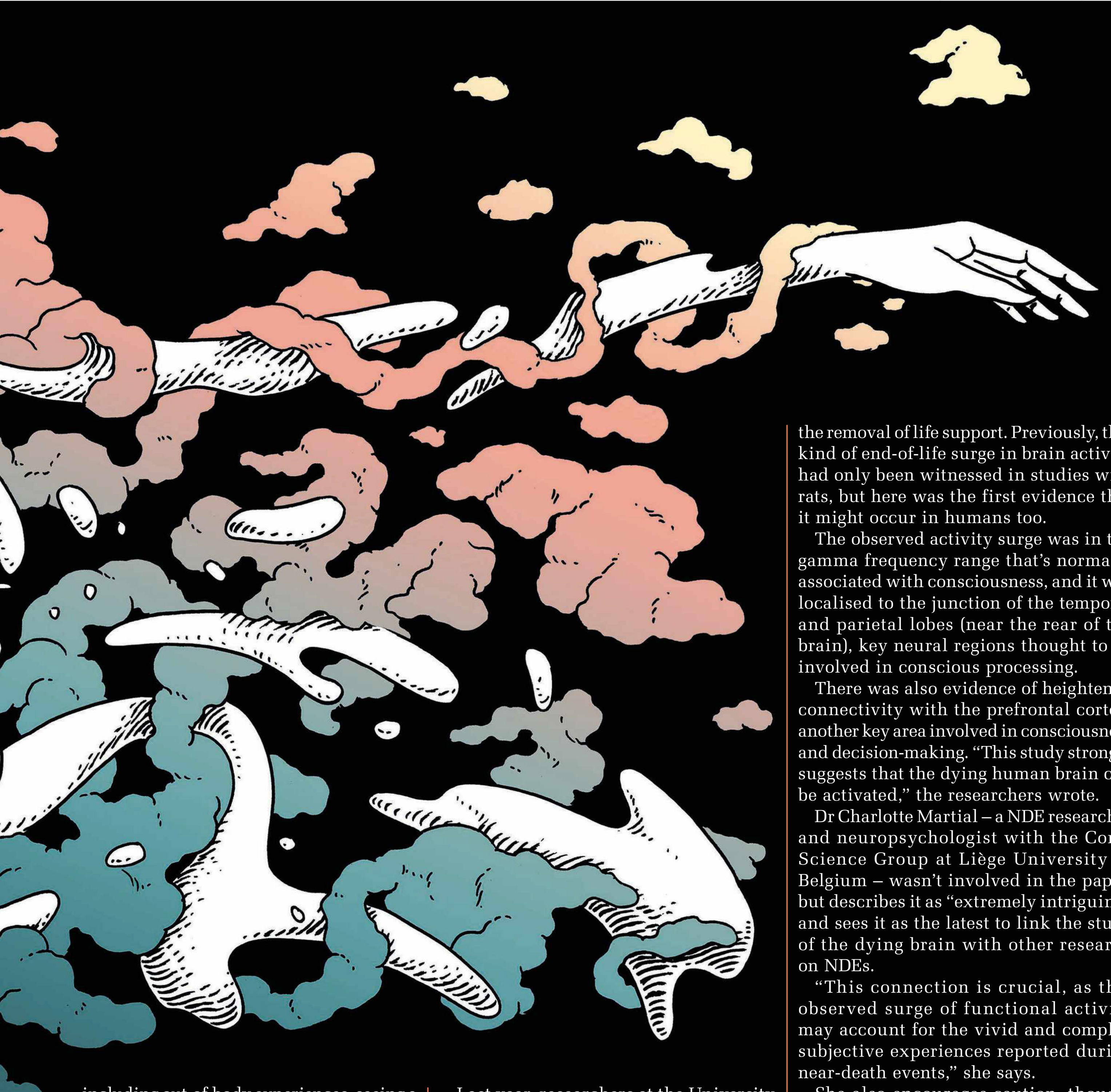
Reflecting on what happened, Tommy says, "I experienced the presence of God. It was overwhelming and occurred in a way that I just don't have language to fully describe."

Similarly, Leanda tells me: "There's no question in my mind that I went to 'the other side', and merged with and had a conversation with the Creator of all that is. I returned with a fraction of that unconditional love, which has never left me."

THE FINAL FLICKERS OF LIFE

By now, scientists have collected thousands of similar testimonies from people who have lived through a NDE. These accounts tend to include several recurring elements,

"IT WAS AS IF I WAS INTERTWINED WITH IT, BUT AT THE SAME TIME IT FELT AS IF IT WAS HUGGING ME"



including out-of-body experiences, seeing a bright light, entering a tunnel, undertaking a life review and feeling a deep sense of peace and relief.

Of course, for many neuroscientists, NDEs may reveal less about the divine and more about the brain's intricate workings. In fact, some neuroscientists argue that many of these powerful subjective experiences can be attributed to intense neurobiological changes occurring as the brain approaches death – and they have the research to support this claim.

Last year, researchers at the University of Michigan published groundbreaking findings from their analysis of brain recordings from four dying patients. The patients were on life support and their brain activity was recorded by electroencephalogram (EEG), which tracks electrical activity in the brain via electrodes placed on the scalp. Led by Dr Jimo Borjigin, the team made the remarkable observation that two of the patients exhibited a surge of brain activity shortly after their relatives had agreed to the removal of life support. Previously, this kind of end-of-life surge in brain activity had only been witnessed in studies with rats, but here was the first evidence that it might occur in humans too.

The observed activity surge was in the gamma frequency range that's normally associated with consciousness, and it was localised to the junction of the temporal and parietal lobes (near the rear of the brain), key neural regions thought to be involved in conscious processing.

There was also evidence of heightened connectivity with the prefrontal cortex, another key area involved in consciousness and decision-making. "This study strongly suggests that the dying human brain can be activated," the researchers wrote.

Dr Charlotte Martial – a NDE researcher and neuropsychologist with the Coma Science Group at Liège University in Belgium – wasn't involved in the paper, but describes it as "extremely intriguing" and sees it as the latest to link the study of the dying brain with other research on NDEs.

"This connection is crucial, as this observed surge of functional activity may account for the vivid and complex subjective experiences reported during near-death events," she says.

She also encourages caution, though, because the patients in this recent study didn't survive and therefore couldn't describe what they'd been through. Perhaps they didn't even have a NDE at all – we just don't know.

A HUGE RELEASE OF CHEMICALS

Although they also can't describe their experiences (whether they survive or not) animals could offer key insights into NDEs. For instance, studies involving rats suggest there's a massive →

→ release of neurotransmitters – chemical messengers that allow nerve cells to communicate – in the dying brain.

For instance, Borjigin's team have previously studied rats in a state of asphyxia (a lack of oxygen in the brain – comparable to when a human has a heart attack) and found that this triggered a sudden release of brain chemicals, including adenosine, dopamine, norepinephrine, gamma-aminobutyric acid, glutamate and aspartate. Serotonin also surged to 20 times its normal levels within just two minutes of asphyxiation.

Given the key roles these chemicals play in emotions and dream-like states, scientists suggest that this swell in neurotransmitters may contribute to the intense subjective experiences reported by people who undergo NDEs.

Further clues that this might be the case come from research using psychedelics – drug compounds that act in the brain and provoke experiences that are reminiscent of aspects of a NDE. These substances include LSD (lysergic acid diethylamide), psilocybin (the hallucinogenic compound in 'magic' mushrooms) and DMT (dimethyltryptamine, the so-called 'spirit molecule' found in several plants located in the Amazon basin). Many of these substances interact with the brain's receptors for neurotransmitters, like serotonin, which can be released in the dying brain.

Martial was part of an international team that questioned volunteers about NDE-like experiences after taking DMT and after taking a placebo pill. The questionnaire included queries about sensations such as feeling as though they had left their body or had seen a bright light. The volunteers' responses were similar to those given by a comparison group who'd actually lived through a NDE.

"One can hypothesise that some endogenous molecules [those made within the human body] mimicking DMT or ketamine mechanisms could be released in life-threatening situations, such as when someone experiences a NDE," says Martial.

"THEY'RE USUALLY LEFT WITH INCREDIBLY INTENSE VIVID MEMORIES OF THE EXPERIENCE"

EVIDENCE OF SOMETHING... MORE

These are exciting developments, but many experts involved in NDEs aren't persuaded by purely neurobiological explanations. Right up until his death in November 2024, Fenwick remained convinced that something more profound is going on. To him, accounts of NDEs provide evidence that the human soul exists beyond the brain.

Similarly, the University of North Texas's Professor Emerita Janice Holden – the current President of the International Association of Near-Death Studies – has serious doubts about the brain research, claiming spikes in serotonin and similar neurotransmitters offer too simplistic an explanation for these profound experiences. "Small, brief, limited brain emissions, even if shown to occur reliably in association with NDEs – which as yet they have not – cannot account for the complex cognition involved in NDEs," she says.

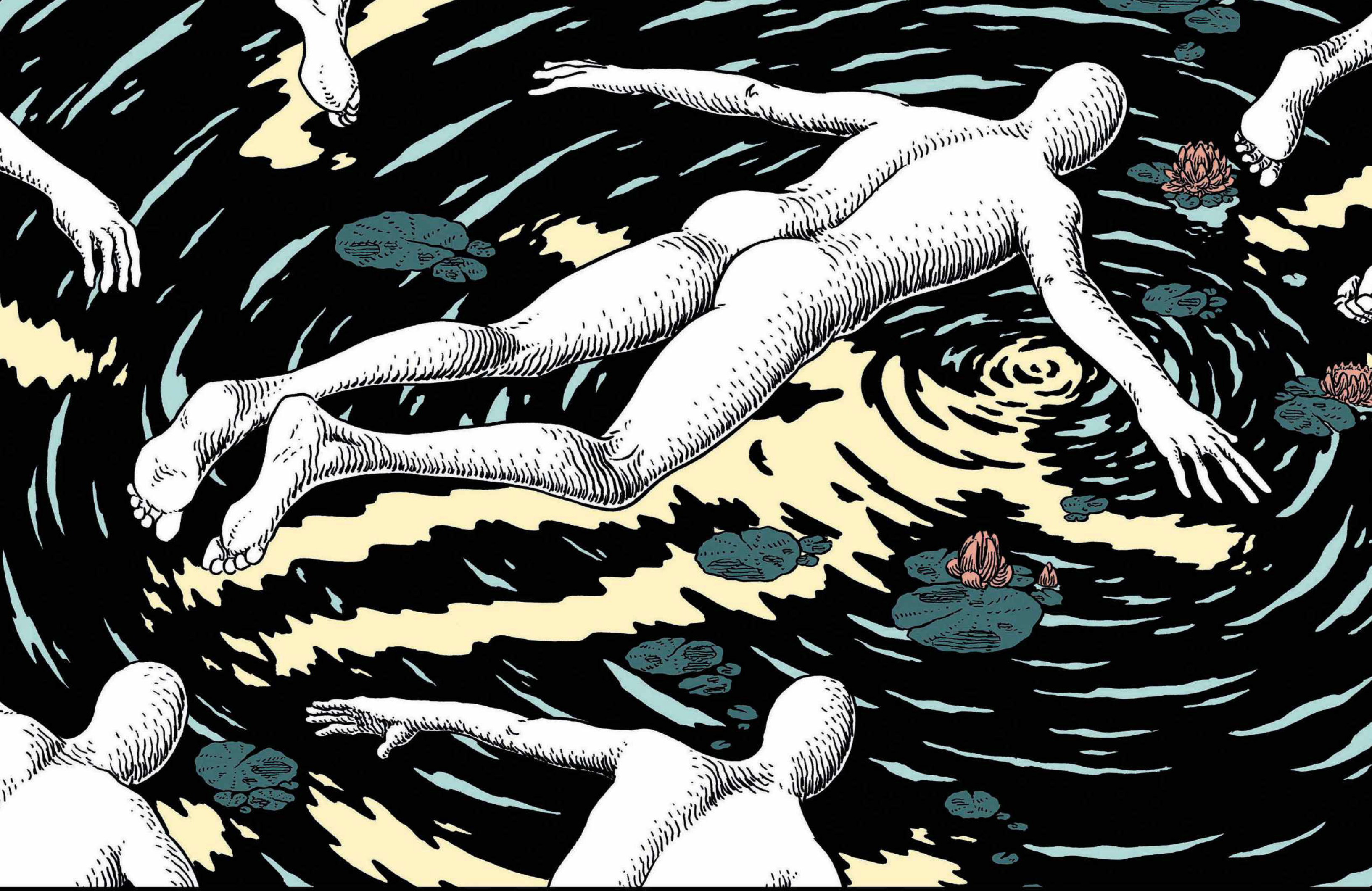
She also adds a surge of neurotransmitters can't explain what the literature refers to as "verified perceptions" from NDEs, such as the ability for the dying person to witness events located elsewhere. "How could a brief gamma wave spike in the brain explain the accurate report of a leg amputation in the operating room next door?" she asks, referencing a case documented by French anaesthesiologist Dr Jean Jacques Charbonier.

(For their part, the neuroscientists say these perceptions have yet to be proven conclusively. "That said, the non-local consciousness hypothesis remains a possibility," concedes Martial. "One we're currently testing in one of our ongoing hospital studies.")

For Holden and many others working in this area, a possibly more important strand of investigation concerns the psychological consequences for people who have lived through a NDE. Studies show they're usually left with incredibly intense and vivid memories of the experience, and many of them report feeling fundamentally changed by what they've been through, including having a profoundly altered attitude to death.

These various after-effects can be divided into several categories, according to Holden. These are: psychological, which includes "changes in values, such as losing a fear of death, becoming less materialistic and more concerned about the welfare of others and planet Earth"; spiritual, "having greatly increased interest in spiritual topics"; physical, "changes in metabolism, appetite, need for sleep, and sensitivity to medication and environment conditions, such as light and sound"; and social, "married NDE-ers are more prone to divorce than the average person, as well as being more likely to change their friends, organisational affiliations and even occupation to better align with their newfound qualities".

Given the profound psychological impact of having a NDE, some mental health experts argue that more should be done to provide support for critical care patients after they navigate the experience. For instance, in 2021, Lilia Samoilo, a mental health and spiritual counsellor, and Dr Diane Corcoran, a past president of the International Association for Near-Death Studies, drew attention to what they called the "medical gap of care" for patients who go through a NDE, with →



“THE SAME TEAM FOUND THAT A VIRTUAL OUT-OF-BODY EXPERIENCE LED TO A REDUCED FEAR OF DEATH”

→ their accounts either routinely ignored, disbelieved or, in some cases, prompting referral to psychiatric care.

“Whenever patients aren’t offered NDE education, their questions go unanswered and they remain in an emotional limbo,” the pair wrote. Their call is arguably all the more urgent given the rising awareness that a significant minority of NDEs can be emotionally distressing – including frightening features, such as hellish visions or experiences of non-existence.

Of course, it’s not possible to deliberately induce NDEs, but one intriguing way that researchers are trying to learn more about the psychological consequences of NDEs is by using virtual reality.

In one study, a team at the University of Barcelona recruited 16 participants to spend time on a virtual island. The experience culminated in the death of their virtual selves and a scenario that involved a virtual out-of-body experience and other elements typical of NDEs, including a life review and travelling through a tunnel towards a light. Compared with a control group, these participants subsequently showed greater selflessness and more concern with global issues rather than materialistic matters. In another study, the same team found that a virtual out-of-body experience led to a reduced fear of death. The team said their work was consistent with the idea that “death might be considered the most extreme example of a ‘transformative experience’”.

As research on NDEs continues, they’ll continue to pose fascinating questions for scientists and philosophers alike. In one of his final interviews before his own death in 2024, Peter Fenwick celebrated the fact that more people are now willing to come forward to talk about their “deep transcendent experiences” near death.

This increased openness about NDEs will assist the work of neuroscientists as they continue to uncover more details of what’s happening in the brain during these transformative moments. As they do so, the debate over whether there can ever be a purely biological explanation is likely to rumble on. But what’s indisputable is the emotional power of NDEs for those who live through them.

“After that NDE experience, my life [will] never be the same,” says Leanda Pringle. “Although it has taken me a long time to fully integrate the experience, the abilities I now possess seem like something from a sci-fi movie. I truly believe I brought some of that realm back with me.” **SF**

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by DR CHRISTIAN JARRETT
Christian is a cognitive neuroscientist, science writer and author. His books include Be Who You Want *(£14.99, Robinson).*

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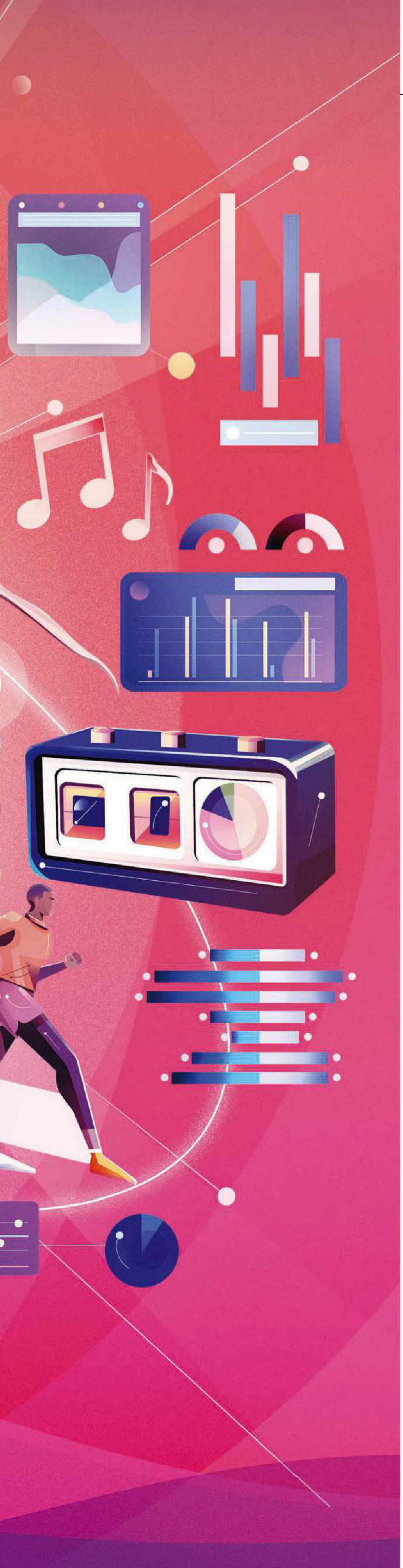


GET HEART SMART

Words by **SOPHIE FREEMAN** Illustration by **JOE WALDRON**

NEW STUDIES HAVE SHOWN THAT SEVERAL SMALL LIFESTYLE CHANGES CAN DRASTICALLY IMPROVE YOUR HEART HEALTH

Modern life isn't doing our hearts any favours. We sit too much (over nine hours a day, on average), are regularly overwhelmed by stress (now linked to chronic inflammation – a key risk for heart disease) and fill more than half of our plates with ultra-processed foods (shown to drastically increase stroke risk). It's little wonder heart disease is now the world's number one killer, accounting for 13 per cent of all deaths on Earth, according to the World Health Organization.

It gets worse. Research suggests that heart disease risk is now rising with each new generation: a University of Oxford study found that people in their 50s and 60s today are up to 1.5 times more likely than their grandparents to develop heart disease at the same age.

Rising obesity rates, as you'd guess, play a role here. But worrying recent research from Harvard Medical School suggests that even people with a normal body mass index could be at risk due to hidden 'fatty muscles'. After studying 700 people admitted to hospital with shortness of breath (but whose arteries weren't clogged), the scientists found that those with more fat lodged in their muscles were more likely to have damage to the tiny blood vessels supplying the heart. Six years later, these people were more likely to be hospitalised for heart disease and had a much higher risk of premature death.

New hidden risks to your heart seem to appear every month. But, reassuringly, so does new evidence for the benefits of keeping your body's hardest working muscle healthy. One intriguing study by University College London, for example, has found that having a healthy heart at age 50 can lower your overall risk of developing dementia, even if you're already experiencing cognitive decline.

Recent research has also suggested better heart health can improve your mental resilience, increase your overall life satisfaction and may even slow ageing. According to the *Journal of the American Heart Association*, adopting 'heart healthy' habits could keep your body biologically young – as measured by DNA methylation (changes in your DNA that occur over time) – while the number of candles on your birthday cake increases.

So, what are the simple habits that'll keep your heart healthy? You'll know the big stuff already: don't smoke, eat less junk food, move more and reduce your alcohol intake. But there's also a trove of little-known, science-backed lessons to help keep your ticker in tip-top shape... →

ILLUSTRATION: JOE WALDRON

TAKE EXERCISE SNACKS

If breaking up your workouts into a series of 10-minute 'bite-size' sessions sounds more doable than a continuous 30-minute routine, know that science is on your side.

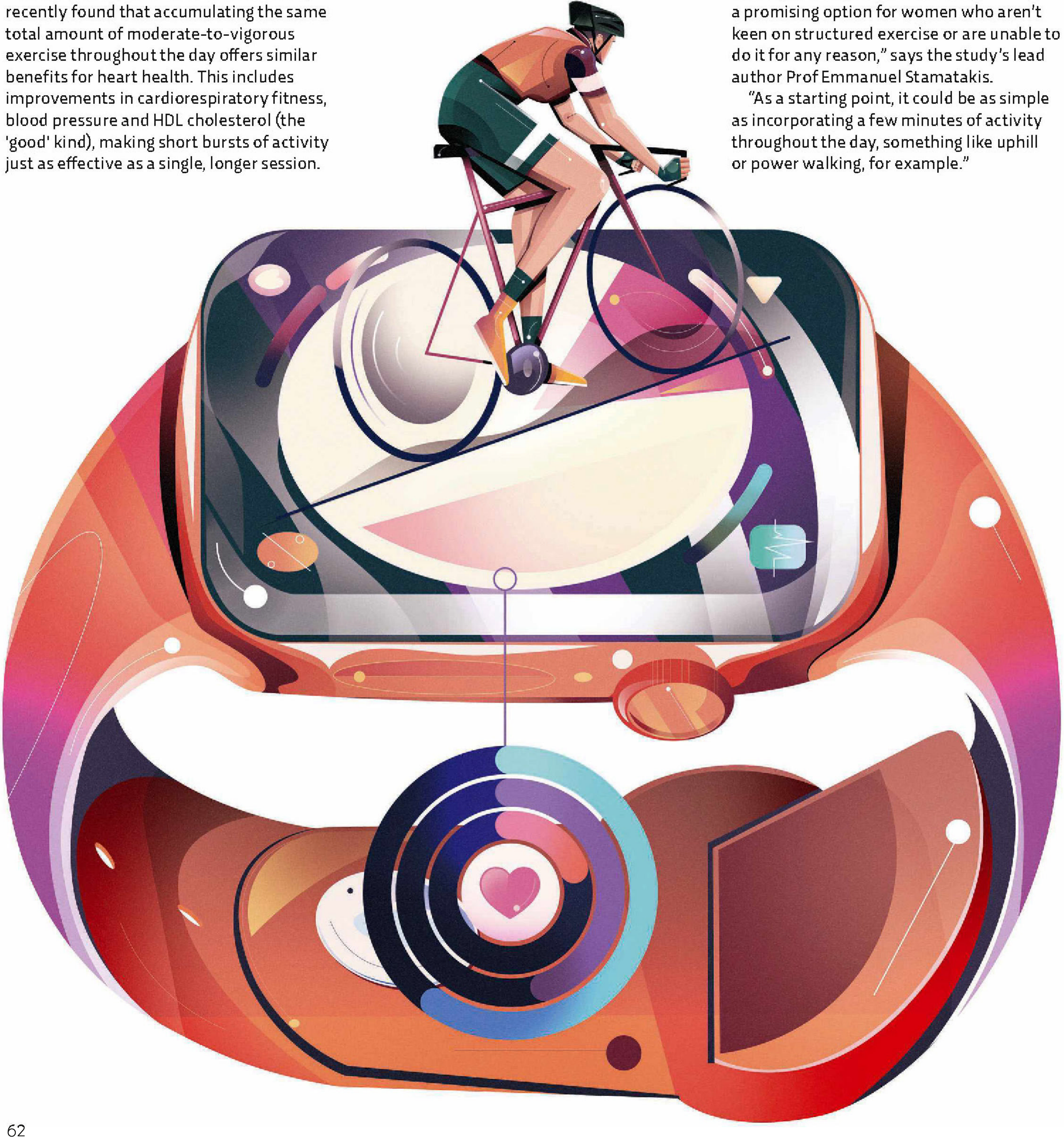
A meta-analysis from Ulster University recently found that accumulating the same total amount of moderate-to-vigorous exercise throughout the day offers similar benefits for heart health. This includes improvements in cardiorespiratory fitness, blood pressure and HDL cholesterol (the 'good' kind), making short bursts of activity just as effective as a single, longer session.

"Splitting a continuous bout of exercise into shorter bouts of equivalent total duration spread over the course of a day doesn't alter its potential to provide health benefits," the Ulster researchers concluded.

Don't have a 10-minute stretch to spare? One University of Sydney-led study suggests that even adding just four minutes a day of vigorous activity – climbing the stairs, say – in chunks of one minute or more can halve the risk of a heart attack for women who are normally relatively sedentary (the results were less clear in men).

"Making short bursts of vigorous physical activity a lifestyle habit could be a promising option for women who aren't keen on structured exercise or are unable to do it for any reason," says the study's lead author Prof Emmanuel Stamatakis.

"As a starting point, it could be as simple as incorporating a few minutes of activity throughout the day, something like uphill or power walking, for example."



SOUND ASLEEP

Whether it's police sirens, trains clattering by or late-night revellers making a racket, nighttime noise is more than just an annoyance – it could be harming your heart.

"After 15 years of research, we're convinced that noise is a cardiovascular risk factor, just like diabetes, hypertension [high blood pressure], high cholesterol or smoking," says Prof Thomas Münzel, an environmental cardiologist at the University of Mainz, in Germany.

"Frequently interrupted sleep causes strong stress reactions, leading to cardiovascular dysfunction."

Coronary artery disease, heart failure, arrhythmia (a problem with the rhythm of the heart), high blood pressure and strokes: Münzel has found your risk of all these conditions is connected to loud and disruptive nighttime noise.

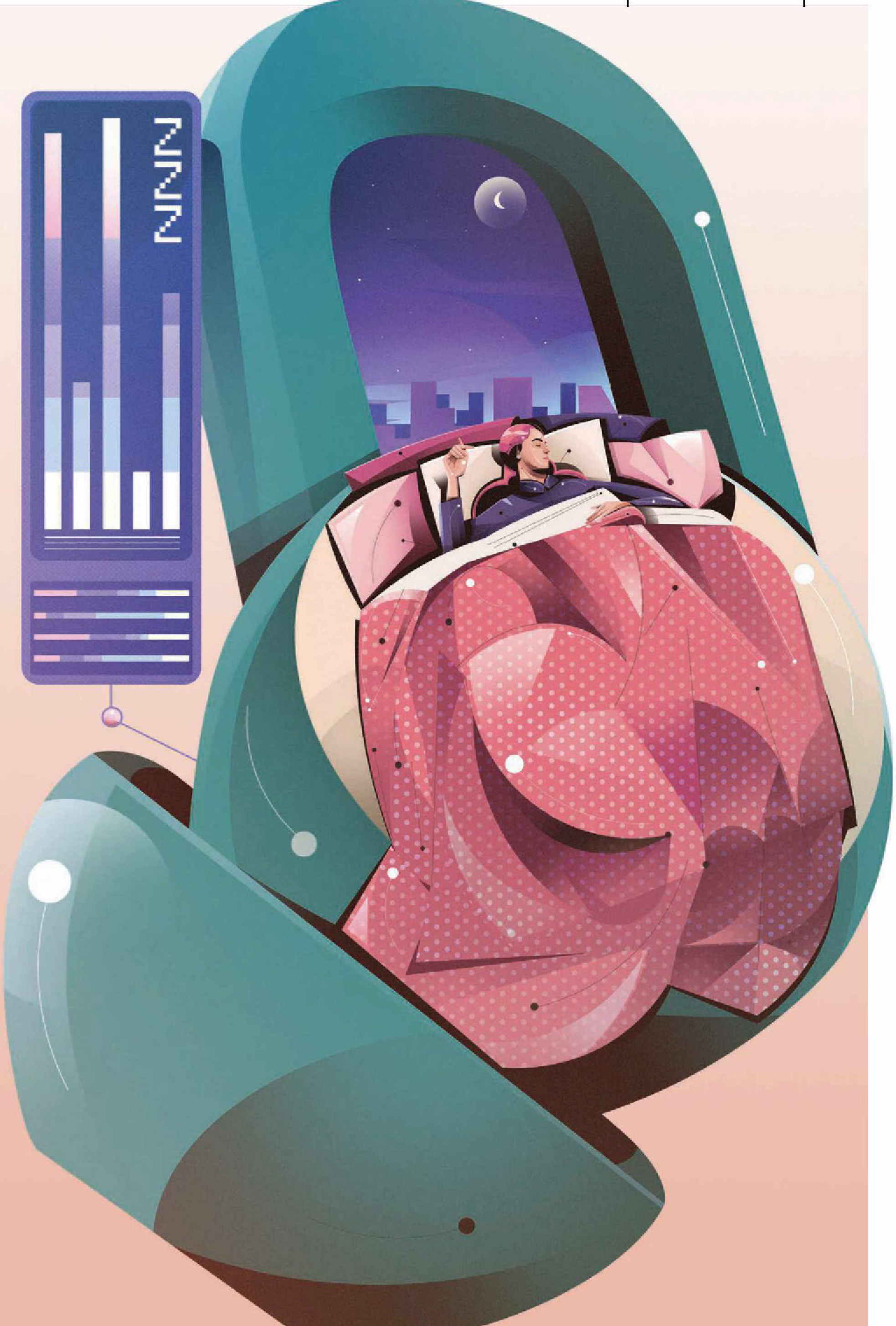
The same is true even if the racket doesn't wake you. Münzel has observed how nighttime noise can trigger your body's stress response when you're sleeping, releasing hormones such as cortisol. Too much of this stress hormone can harm your blood vessels over time, mainly by causing oxidative stress. This happens when harmful molecules (free radicals) outnumber protective ones (antioxidants), leading to cell damage.

Hearing loud noise while you're sleeping also prevents the natural dipping of blood pressure, the absence of which is linked to increased risk for cardiovascular disease.

It's no surprise, then, that an analysis of 25,000 heart-related deaths near Zurich Airport (2000–2015) found that planes passing overhead at night were linked to higher death rates, especially in women.

Concerned? If so, check the sound levels around your bed (try a free Decibel Meter app on your phone) – Münzel has found that a single night of sleeping in a room with 30 decibels of noise – equivalent to the sound of people talking quietly – is enough to impair blood vessel function.

If your bedroom is too loud, consider finding a quieter room. Or just wear earplugs. As one Australian study suggested, do this and your cardio system could see the benefits in as little as a week.



"AN ANALYSIS OF 25,000 HEART-RELATED DEATHS NEAR ZURICH AIRPORT FOUND THAT PLANES PASSING OVERHEAD AT NIGHT WERE LINKED TO HIGHER DEATH RATES, ESPECIALLY IN WOMEN"

ILLUSTRATIONS: JOE WALDRON

SING YOUR HEART OUT

Keeping your heart healthy can start as soon as you get out of bed and step into the shower. As long as you belt out a few musical numbers while you're washing. That's according to several studies, including research by the Medical College of Wisconsin that found singing for 14 minutes a day could have a similar positive impact on your heart rate variability (HRV) as light exercise.

As anyone with a fitness tracker will know HRV – the variation in the time between heartbeats – is one of the key hallmarks of cardio health. A high HRV indicates your body is more resilient and adaptable to stress.

"Physiologically, singing involves controlled diaphragmatic breathing and sustained exhalation, which improve respiratory function," says Ragavendra Baliga, a cardiologist and professor of internal medicine at Ohio State University, in the US.

He adds that singing mimics exercise by "increasing oxygen consumption and heart rate while fostering synchronisation between heart rhythms and respiration, a calming effect known as respiratory sinus arrhythmia."

Singing with friends and family might be even better for your cardio health (though maybe step out of the shower for this). "Group singing, in particular, enhances emotional wellbeing through social connection and collective rhythm," says Baliga.

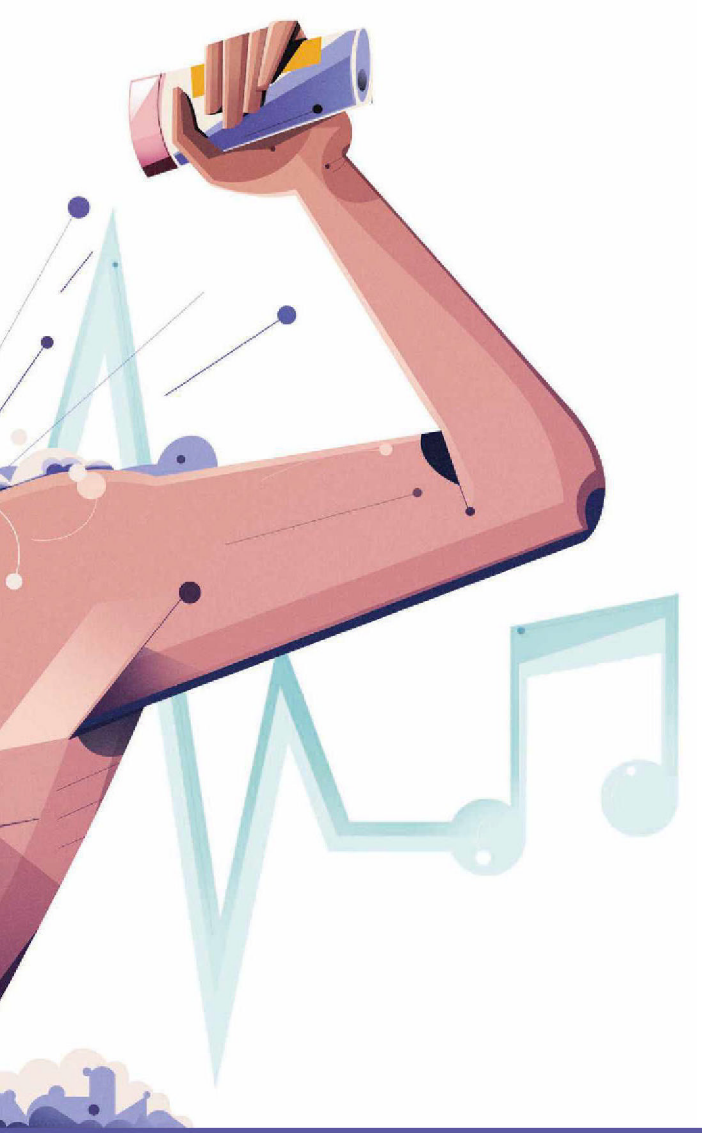
"Positive emotional states reduce stress and anxiety, which lowers the activation of the sympathetic nervous system and stress hormones such as cortisol and adrenaline," he adds. "This, in turn, decreases blood pressure and systemic inflammation – factors that contribute to cardiovascular disease."

GO WITH YOUR GUT

You've probably heard that the Mediterranean diet is a good one to follow. In fact, you'll likely roll your eyes if we say you should add more vegetables, beans, whole grains and fish to your plate. But we've got good reason to keep bringing this up.

New research has uncovered a surprising connection between your gut microbiota (the vast community of microbes living in your gut) and the build-up of fatty deposits in your arteries, a process scientists call 'furring'. In other words, what's on your dinner plate may influence your heart health in ways you never expected.

"In all cardiovascular diseases, there are studies showing that gut microbiota modulate their development," says Dr Meritxell Nus Chimeno, a British Heart Foundation research fellow at the University of



Cambridge. The key to bettering the relationship between your gut and heart? A diverse microbiota, according to Nus Chimeno.

"You want to avoid a dramatic imbalance in the composition and function of these microorganisms – what's called gut dysbiosis. This can lead to a 'leaky gut' [when the barrier between the gut and the bloodstream breaks down] and systemic inflammation causing obesity and cardiovascular disease," she explains.

"Many studies have demonstrated that a diverse gut can be achieved with a diverse Mediterranean-type diet, rich in all sorts of fruits, vegetables, fish and olive oil."

The link between your gut and heart health is now so robust that a major review from Italy's University of Palermo has concluded that "promoting the adoption of the Mediterranean diet could be an effective strategy for mitigating the burden of cardiovascular disease globally."

ILLUSTRATIONS: JOE WALDRON

MIND THE NAP

Many past studies have suggested that an afternoon nap is great for your heart. One large study, carried out by a team at the University of Athens, found that apparently healthy people, particularly working men, who took a siesta were less likely to have died from a heart problem when followed up with six years later.

But there are caveats. The biggest is that benefits disappear if you nap for too long. A meta-analysis by scientists at the University of Tokyo, for example, found a daily snooze of more than 60 minutes was linked to a higher risk of death from a heart problem.

So, what exact physiological changes does napping have on your heart? Here lies the problem. A lot of the research that's been done on napping is observational, so it can't show cause and effect. A long nap, in itself, might not be harmful, but it might be a reflection of poor sleep at night. In short, it's important to consider the reasons you fancy those 40 winks mid-afternoon.

"As we age, we tend not to need as much sleep at night and some older people also have a nap in the afternoon – that's okay. A concern would be when there's something, such as sleep apnoea, that's making a person tired in the afternoon," says Chris Gale, a professor of cardiovascular medicine at the University of Leeds.

Sleep apnoea is where the throat relaxes and becomes narrow or closed during sleep, thus interrupting normal breathing. And it's a big problem for your heart. "It's associated with cardiovascular diseases including high blood pressure, heart failure, atrial fibrillation and stroke," says Gale. "Sleep apnoea can mean you have a poor night's sleep without realising it, causing you to nod off during the daytime."

Signs to look for include habitual snoring and having a thick neck, which is classed as 43cm (17in) or more in men and 41cm (16in) or more in women.

LONELY HEARTS CLUB

Loneliness isn't just bad for your mental health, it can take a serious toll on your heart. One major meta-analysis by the University of York found that lonely older adults have a 29-per-cent increased risk of coronary heart disease. Looking specifically at heart failure, where the heart is unable to pump blood around the body properly because it's too weak or stiff, a 2023 study of the UK Biobank revealed that socially isolated or lonely people had a 15–20-per-cent higher risk.

Interestingly, the same study found whether or not a person felt lonely was more important than if they were actually alone. Subjective loneliness appears to be a stronger psychological (and therefore cardiovascular) stressor than social isolation, likely because it often occurs in people who experience "hostile or stressful social relationships", the study concluded.

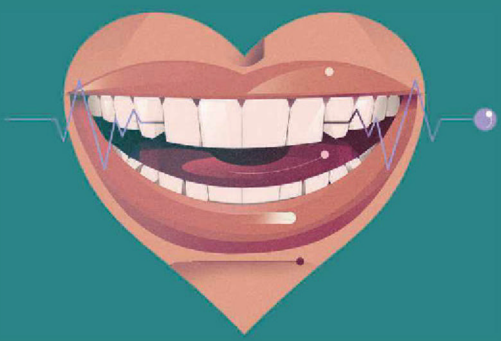
There's physiological evidence to support this. Further research from the University of Cambridge has found higher levels of certain brain proteins in people who feel lonely.

"Loneliness, being a chronic stressor, has actions on proteins involved in the stress response and the cardiovascular system in particular," says Prof Barbara Sahakian, one of the scientists involved in the research.

"There's evidence for a link between stress, heart disease and stroke. Stress can cause increased blood pressure and also has other damaging effects that can lead to a heart attack or stroke."

So, how can you feel less lonely? One step is to be kinder to the people you already know: one Australian paper found people who performed small daily acts of kindness for their neighbours each day (mowing their lawn, offering them meals or simply talking to them) significantly reduced their feelings of loneliness in just four weeks.

If you'd rather not speak to the neighbour who insists on playing his drum kit at 2am (thus impacting your heart health), consider joining a volunteer group instead. A study of 13,000 US adults discovered that those who volunteered at least 100 hours per year had a significantly lower risk of dying from a cardiac event over four years, compared to non-volunteers. The same study also recorded much lower levels of depressive symptoms in volunteers. In other words, lending a hand could save your heart in more ways than one.



DENTAL CLARITY

Spotted blood in the basin when brushing your teeth? It could be a sign of a lot more than just gum trouble.

"There's reasonably good evidence that gingivitis [gum inflammation] is associated with cardiac disease," says Prof Chris Gale. Gingivitis occurs when plaque – a sticky film of bacteria – builds up on teeth, releasing toxins that irritate the gums. Left untreated, this can lead to chronic inflammation, which is associated with atherosclerosis, a condition where fatty deposits narrow the arteries, increasing the risk of cardiovascular disease.

If you notice a problem, speak to your doctor or dentist. But the best approach is prevention.

> "PEOPLE WHO FLOSS AT LEAST ONCE A WEEK HAVE A 44-PER-CENT LOWER RISK OF STROKE"

A 2025 study, presented at the American Stroke Association's International Stroke Conference, found that people who floss at least once a week have a 44-per-cent lower risk of cardioembolic stroke (caused by blood clots travelling from the heart) and a 12-per-cent lower risk of atrial fibrillation (an irregular heartbeat that raises stroke risk). These benefits were seen regardless of whether participants also brushed their teeth regularly (twice a day).

Of course, correlation isn't causation: the people who engage in other healthy behaviours are also more likely to floss. Still, if your teeth or gums show signs of trouble, it might be time to check in on your heart health, too. Indeed, the European Society of Cardiology argues that dental screening programmes, including regular check-ups and education on proper dental hygiene, may "help to prevent first and subsequent negative heart events." **SF**

by SOPHIE FREEMAN

Sophie is a science writer who specialises in health and psychology.

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ECHOES O

OVER HALF A MILLION PEOPLE MAY HAVE LIVED IN THE LOST LANDSCAPES NORTH OF AUSTRALIA… BEFORE THEY WERE CONSUMED BY THE OCEAN

by **DR CLAIRE ASHER**

In the works of Plato, a Greek philosopher who lived around 2,400 years ago, the island of Atlantis was said to have been drowned in the Atlantic Ocean after the hubris of its people angered the Gods. Although Atlantis was fictional, the idea that entire civilisations can disappear beneath the waves has intrigued us for millennia. Now, innovative technologies are revealing real sites around the world that our ancestors were forced to abandon before they were swallowed by the oceans.

One such ‘Atlantis’ lies to the north of Australia. At the height of the last Ice Age, around 21,000 years ago, the continent of Australia was around 20-per-cent larger than it is today. With more water locked up in ice sheets and glaciers, sea levels were around 120m (394ft) lower. This exposed an additional 2,000,000km^2 (around 772,000 sq miles) of land that connected Australia to New Guinea in the north and Tasmania in the south, creating a supercontinent known as Sahul.

Sahul’s Northwest Shelf was a vast landmass that covered 400,000km^2 (154,000 sq miles) – just over 1.5 times the size of the UK – and joined onto the modern-day Kimberley region in northern Western Australia, and the Arnhem Land region in →

ILLUSTRATION: MAGIC TORCH

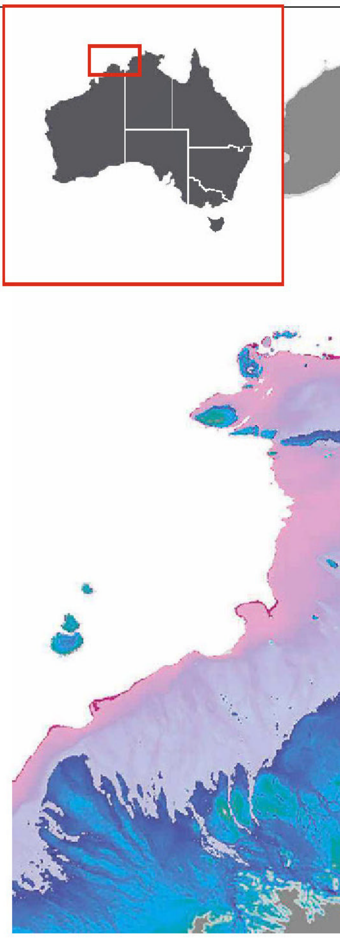
F ATLANTIS

→ Australia's Northern Territory. Many archaeologists have argued that these ancient landscapes were unproductive environments and weren't used much by the early Aboriginal people. But new research is challenging this long-held assumption.

The now-submerged region may also hold the secrets to one of the biggest puzzles in anthropology. Lying next to some of the oldest known archaeological sites in Australia, Sahul's Northwest Shelf has long been recognised as a likely point of entry for the first people who made their way to the continent, some 65,000 years ago.

Now, the race is on to uncover the hidden treasures of this Atlantis-like land, before they're destroyed forever.

"HUNDREDS OF GENERATIONS OF PEOPLE LIVED OUT THEIR LIVES ON LANDS THAT ARE NOW SUBMERGED BY THE SEA"



REVEALING LOST LANDSCAPES

About 27,000 years ago, as the planet descended into the last Ice Age, the polar ice caps grew and the sea level dropped, exposing the low-lying landscapes of Sahul's Northwest Shelf for the first time in 100,000 years.

"Archaeologists have only been able to speculate about the nature of the drowned landscapes people roamed before the end of the last Ice Age, and the size of their populations," says Dr Kasih Norman, a researcher at the Max Planck Institute of Geoanthropology.

Norman led a recent study that combined sonar data with computer modelling to examine the Northwest Shelf in unprecedented detail. The team overlaid estimates of past sea levels on existing high-resolution maps of the ocean floor to visualise what the region would have been like tens of thousands of years ago.

Their analysis revealed a rich and varied landscape of rivers, lakes, valleys and gorges. "Seeing those drowned landscapes and imagining the people that roamed across them during the last Ice Age really fired my imagination," Norman says. The region also boasted a large inland sea, called the Malita Sea, which covered an area of more than 18,000km^2 (7,000 sq miles).

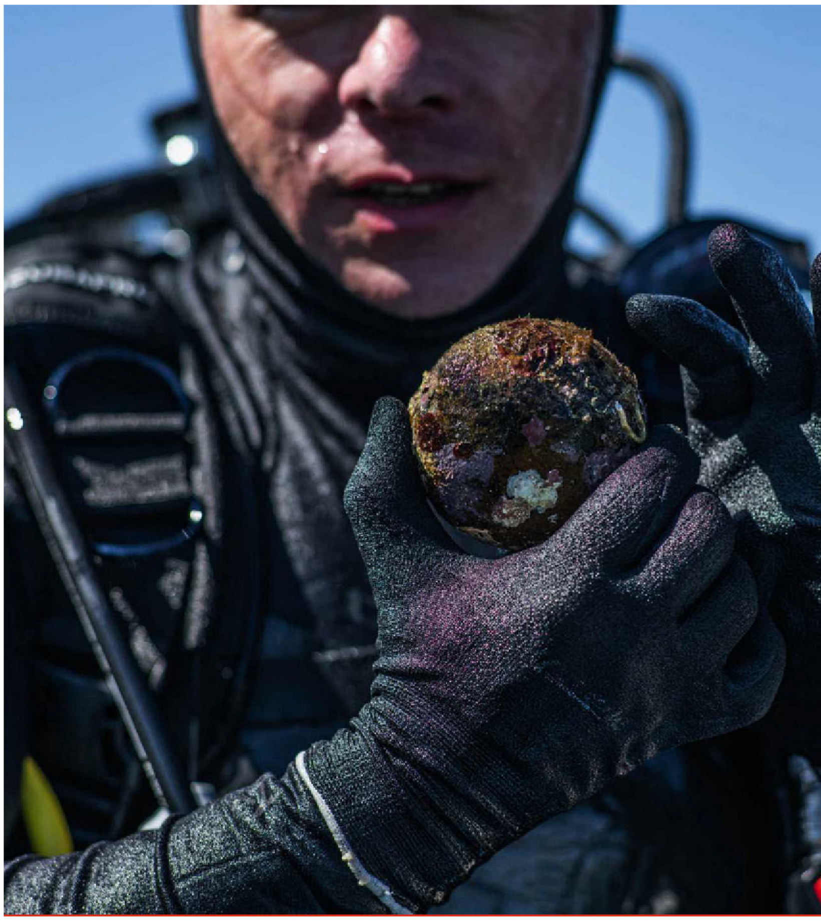
These new data "provide the texture necessary to begin to build a picture of the way these now-submerged landscapes were used and given meaning by societies over tens of millennia," says Prof Sean Ulm from the Australian Research Council's Centre of Excellence for Indigenous and Environmental Histories and Futures at James Cook University, who specialises in coastal and underwater archaeology.

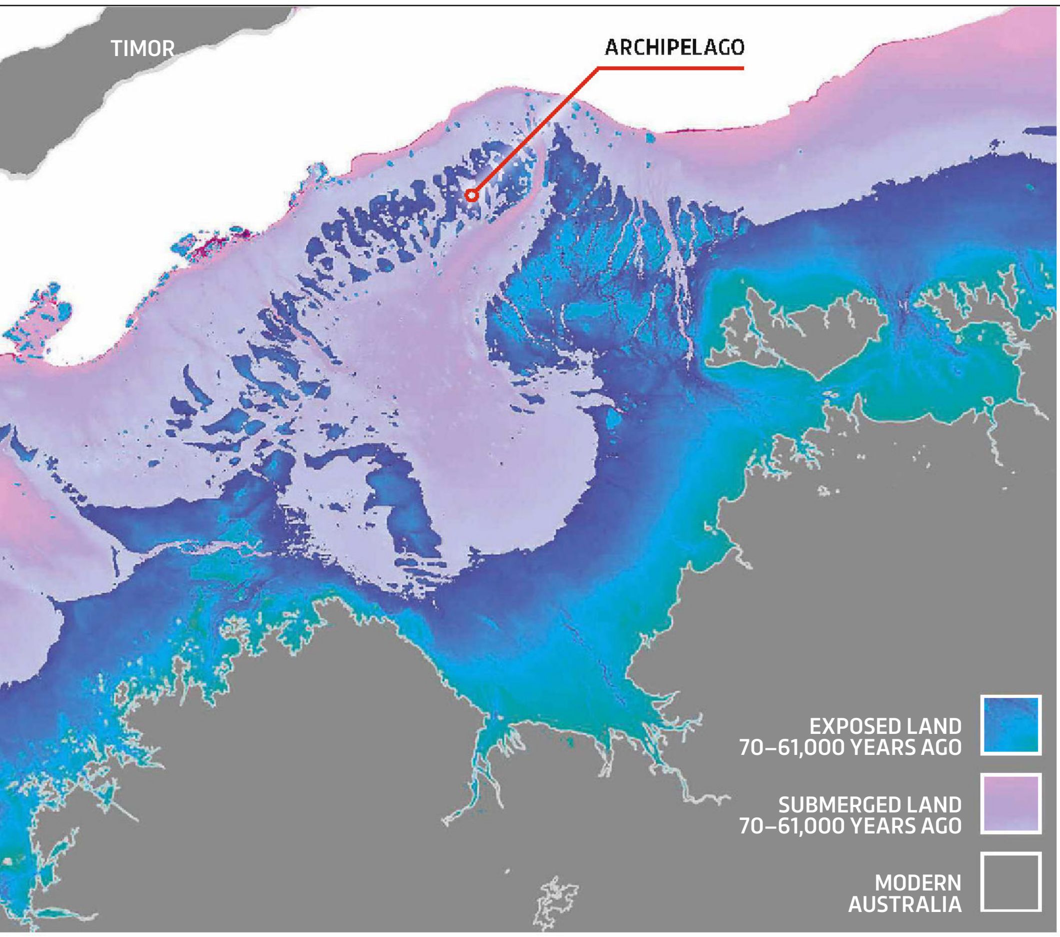
TRACING A DROWNED CIVILISATION

Norman and her colleagues used computer modelling to estimate how productive these landscapes would have been and how many people could have lived there, between 71,000 and 15,000 years ago. They found that at the height of the last Ice Age, when the entire Northwest Shelf was dry land, the region had the capacity to support a population of more than 500,000 people.

On several islands that remain, dotted along what was once the coast of Sahul, archaeological evidence supports the theory that the Northwest Shelf was used regularly by Aboriginal societies.

The team's population estimates are also in line with a recent study of genetic data from Indigenous people living on the Tiwi Islands, which lie to the east of Sahul's Northwest Shelf. That study found evidence of a large population on the islands 20,000 years ago, followed by a population decline at the end of the last Ice Age.

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ARCHIPELAGO
EXPOSED LAND 70–61,000 YEARS AGO
SUBMERGED LAND 70–61,000 YEARS AGO
MODERN AUSTRALIA

ABOVE An illustration showing how the coastline of Sahul differed to that of present-day Australia

FAR LEFT A diver on the Deep History of Sea Country Project shows a stone artefact recovered from the seabed

LEFT An Aboriginal elder from Australia's Tiwi Islands

What were the lives of the people who lived in this now-submerged landscape like? "This is really the fundamental question," Ulm says.

"There's extraordinary social, cultural and technological diversity among contemporary and recent Aboriginal societies. We have to assume that was also the case in the past," he says.

"What we do know is that these societies that lived on the emerged continental shelves [of Australia] travelled long distances to and from the coast, and were connected with other distant inland societies through trade networks," he explains.

Norman and her colleagues say that similarities in stone axe technology, rock art styles and languages suggest that the modern-day regions of the Kimberley, Arnhem Land and the now-flooded Northwest Shelf of Sahul together formed one huge interconnected cultural region during the height of the last Ice Age.

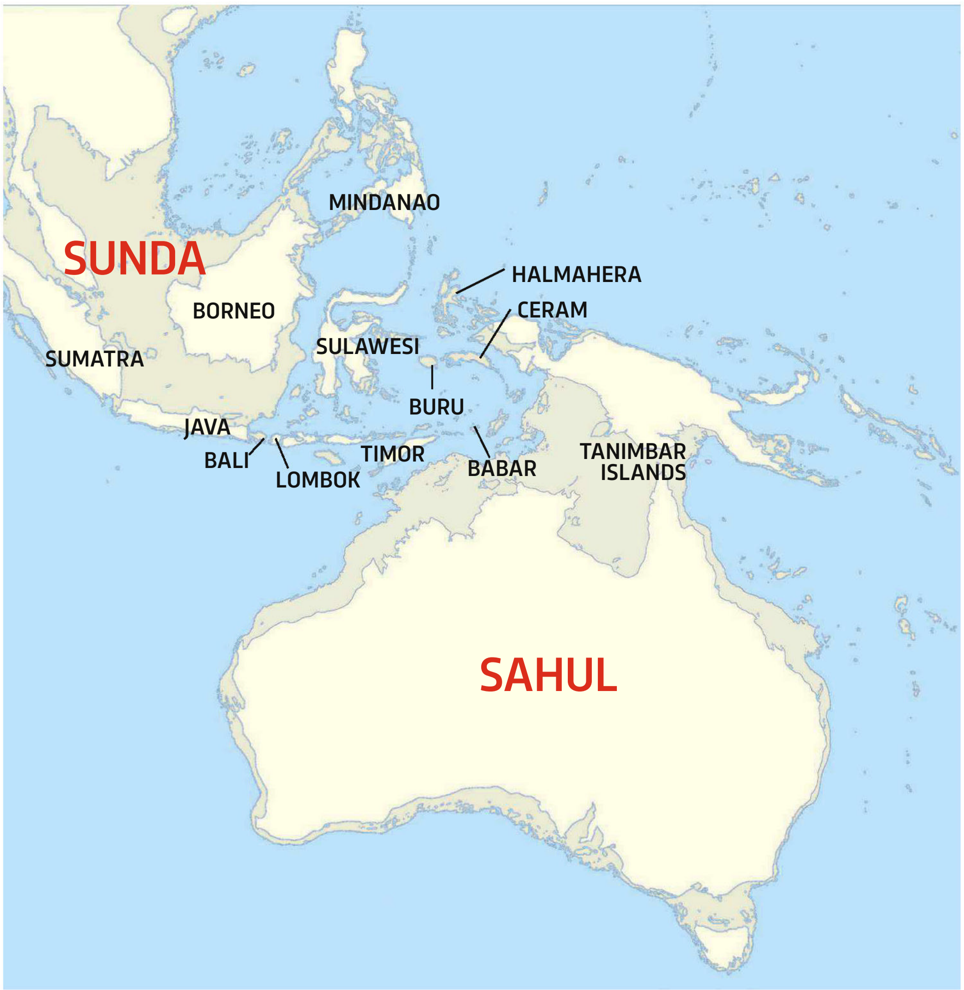
RECOVERING ANCIENT TREASURES

Part of the reason we know so little about the culture and lifestyle of the people of the Northwest Shelf is because the relics from their ancient societies are now hidden below the water. "Hundreds of generations of people lived out their lives on lands that are now submerged by the sea," says Ulm.

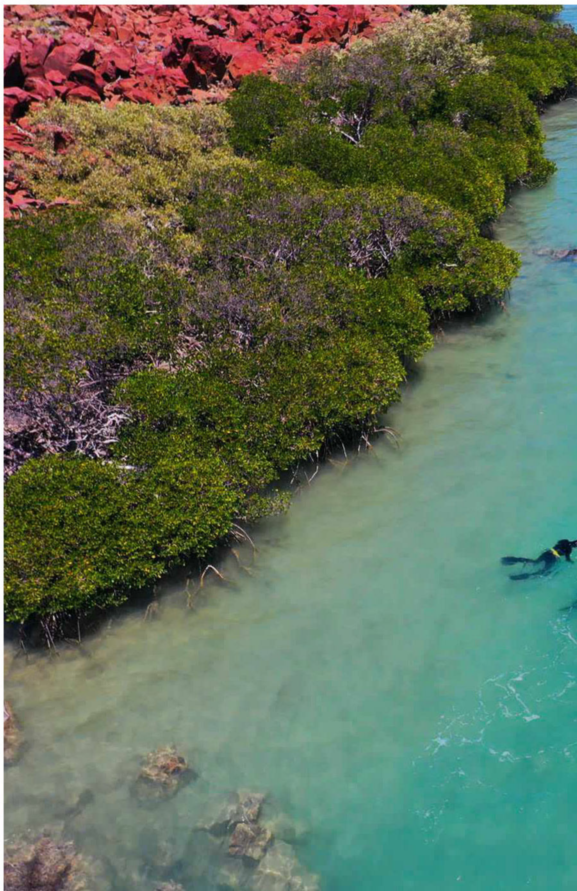
Archaeologists now have more tools available to locate ancient underwater sites and learn more about the lives of the people whose homes were lost to the ocean thousands of years ago.

"Most submerged cultural places around the world examined by archaeologists were first found by others by accident," Ulm says. "[But] in the past few decades, more structured approaches have emerged, using many lines of evidence to develop predictive models of where sites and landscapes might be preserved underwater."

Ulm was part of a team of archaeologists, rock art specialists, geomorphologists, geologists, specialist pilots and scientific divers that collaborated with the Murujuga Aboriginal Corporation – which brings together members from five traditional Aboriginal groups – to explore submerged archaeological sites off the coast of the Pilbara region of Western Australia. The team used navigation charts, geological maps and known archaeological sites on land to identify potential sites on →



KANGUOLE/WIKIPEDIA, ALAMY, JEREM LEACH/DEEP HISTORY OF SEA COUNTRY, J BENJAMIN/ DEEP HISTORY OF SEA COUNTRY



→ the seabed to explore. At these sites, they used laser scanners and sonar to gather high-resolution maps of the ocean floor that further narrowed down their search. Scientific divers then conducted underwater archaeological surveys at the most promising sites.

All this hard work paid off, and in 2020 they reported the discovery of the first submerged ancient Aboriginal archaeological sites, where they recovered nearly 300 stone artefacts. These included tools for cutting and grinding, which had lain on the seabed for at least 7,000 years before their discovery.

Unfortunately, many other artefacts like these may be destroyed before we have a chance to find and recover them. Submerged archaeological sites around Australia are under threat from coastal and offshore developments, including oil and gas exploration, renewable energy infrastructure and industrialised fishing.

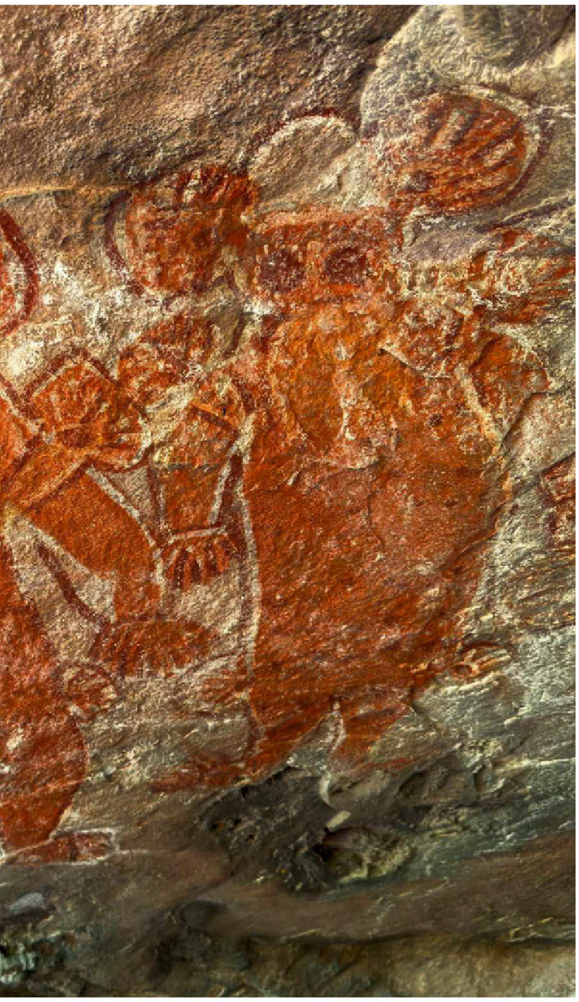
"In the last couple of years, Aboriginal and Torres Strait Islander communities have worked with archaeologists to mitigate the impacts of development on their submerged cultural heritage," Ulm says.

Indigenous groups and archaeologists are calling for stronger protections for these sites, which generally fall outside existing legislation in Australia that was designed to protect historic sites (such as those containing shipwrecks and sunken aircraft) from the modern era.

ANCIENT MARITIME EXPLORERS

How and when the first people arrived in Australia is one of the biggest unanswered questions in anthropology, and the Northwest Shelf is a key piece of this puzzle. We now know that humans first arrived on the continent at least 65,000 years ago, and the most likely routes took them from southeast Asia to Sahul via modern-day Indonesia.

At this time, lower sea levels had exposed a long chain of more than 100 habitable islands on the Northwest Shelf between Indonesia and Sahul, which "may have



> “BETWEEN 18,000 AND 8,000 YEARS AGO, OVER 2,000,000KM² OF AUSTRALIA WAS FLOODED. COASTLINES AROUND THE CONTINENT RETREATED BY OVER 100KM IN MANY PLACES”

FAR LEFT A a map showing how much more land was exposed before the sea rose at the end of the last Ice Age

LEFT Wandjina art found in the Wunaamin Miliwundi Ranges, in the Kimberley, Western Australia

BELOW Archaeologists working off the coastline of Western Australia

BELOW RIGHT A stone artefact identified by the Deep History of Sea Country Project team

enabled staged human dispersal from Indonesia to Australia, with people possibly using the archipelago as stepping stones,” Norman says. These islands would have been visible from high ground on the islands of Timor and Roti, offering a clear target for the explorers to aim for.

However, this still required a sea crossing of nearly 90km (56 miles), which is two or three times longer than the voyages needed to reach Timor or Roti, and would have taken several days. This suggests that the first Australians were skilled seafarers, capable of constructing maritime vessels as well as planning and navigating multi-day journeys. Although we’ll likely never know exactly where people first arrived in Australia, the site where these intrepid explorers made landfall is likely to be at least 60m (197ft) underwater today.

Experts say that a group of more than 1,000 settlers must have made the journey, otherwise they would have been unlikely to survive long-term. This initial founding population adapted to and thrived in Australia’s landscapes, spreading out across the newly discovered continent and flourishing into an estimated population of about 2.5 million people by the time European colonists arrived in the late 1700s.

A study published in 2024 used computer modelling to investigate the most likely routes taken by people as they dispersed across Sahul. It pointed to waves of dispersal radiating out across the continent, following river corridors and coastlines.

ADVANCING OCEANS

As the last Ice Age came to an end, around 18,000 years ago, melting ice sheets and glaciers released millions of cubic litres of water into the world’s oceans. This caused sea-level rise on a scale unparalleled in human history. Over a period of around 10,000 years, coastal areas were progressively submerged and the continent of Sahul was split into what’s become New Guinea and Australia.

Between 18,000 and 8,000 years ago, over 2,000,000km² (around 772,000 sq miles) of Australia was flooded. Coastlines around the continent retreated by over 100km (62 miles) in many places. Indigenous histories from around the coast of Australia tell of the drowning of vast coastal landscapes, which researchers believe are a record of these events. This makes them the world’s longest-known continuous oral histories, which have been passed down →

→ from generation to generation for over 10,000 years.

But the climate warming and the sea level rise it caused wasn't a smooth, continuous process – it came in pulses. The first pulse began around 14,000 years ago and lasted about 400 years. In that relatively short time, 100,000km^2 (around 38,600 sq miles) of the Northwest Shelf flooded – an area roughly the size of Ireland. A second, more gradual period of melting between 12,000 and 9,000 years ago flooded a further 100,000km^2 of the Northwest Shelf.

At times, people would have witnessed the ocean advancing by more than 20m (66ft) a year. "Such rapid and catastrophic marine inundation would have had profound effects in the space of a single human lifetime," Norman says.

"Rising seas would have caused the coastline to migrate rapidly, compelling people to fall back as marine waters submerged once-productive landscapes." Retreating coastal populations would have been forced together into a much smaller land area.

Based on the land area lost and population size estimates for the whole continent, a 2018 analysis estimated that population densities across Australia more than doubled in the 10,000 years after the end of the last Ice Age. Several inland archaeological sites have been dated to this time, suggesting that many Aboriginal populations abandoned their coastal homes and moved inland.

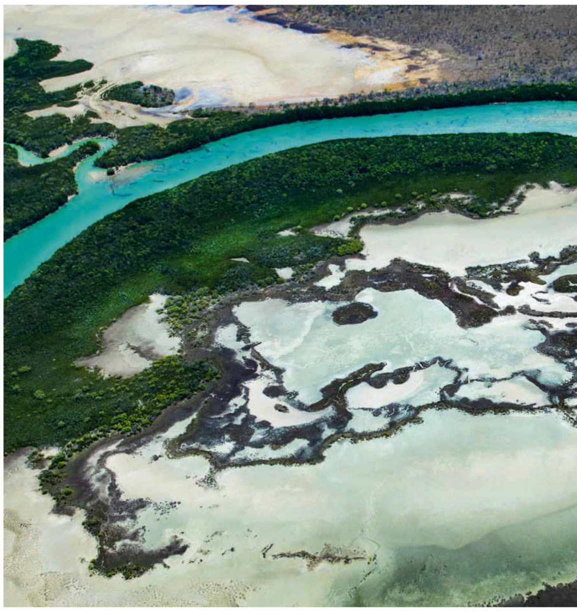
The archaeological record shows hints of the significant cultural impact of this rapid influx of people. For example, in the neighbouring regions of the Kimberley and Arnhem Land, archaeologists have documented sudden increases in the number of artefacts left behind, and new styles of rock art appearing, that coincide with the two great pulses of sea level rise.

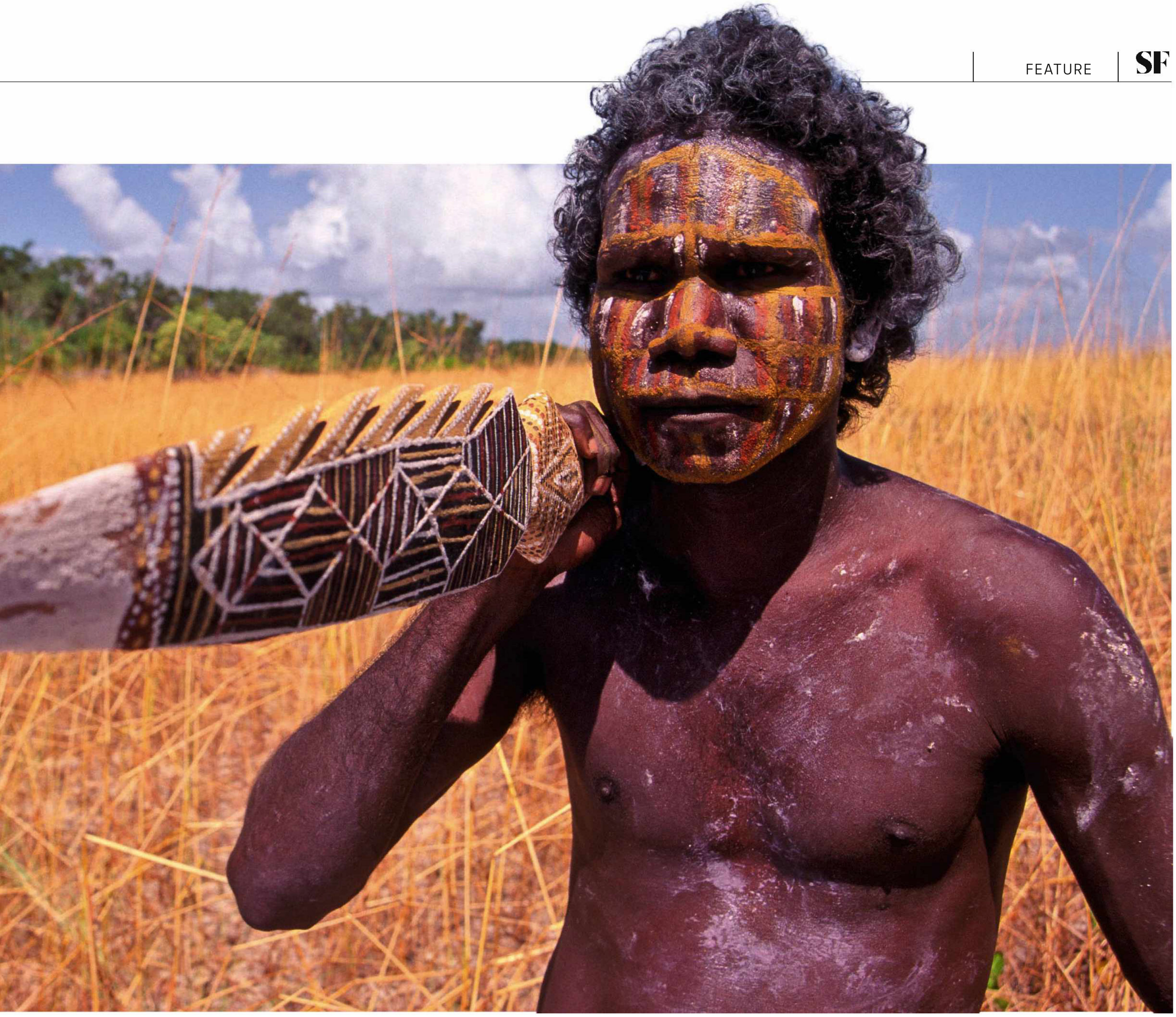
LOOKING TO THE FUTURE

With global sea levels predicted to rise by more than 1m (3ft) by 2100, humanity is once again facing the prospect of losing large amounts of coastal land. Studies like these remind us that although climate change presents enormous challenges, human populations have survived rapid environmental change in the past.

Around the world, many ancient cultural sites have been discovered below the ocean's surface – lost to sea

> "SUCH RAPID AND CATASTROPHIC MARINE INUNDATION WOULD HAVE HAD PROFOUND EFFECTS IN THE SPACE OF A SINGLE HUMAN LIFETIME"





ABOVE An Aborigine hunter from the Tiwi Islands, Australia

FAR LEFT Dr Kasih Norman, one of the archaeologists investigating the lost landscapes submerged off the northwest coast of Australia

LEFT A view of the Tiwi Islands from the air

ALAMY, GETTY IMAGES, KASIH NORMAN

level rise just like Sahul's Northwest Shelf. "There's plenty of archaeological evidence that humans once lived in areas that are now submerged all around the world," says Norman.

Archaeological finds demonstrate that during the last Ice Age, humans made use of new landscapes exposed by the retreating ocean, including Doggerland in the North Sea, the Baltic Sea in northern Europe, and sites along the coasts of the Mediterranean, North and South America and South Africa. And then the rising waters forced them to retreat inland – sometimes at a pace that seems inconceivable today.

Modern populations are much larger, however, and many of our urban centres are on the coast, which will make adaptation even more difficult. The archaeological record also shows us that rapid climate change had a profound impact on the people who lived through it.

If we can learn from past societies, we may be better equipped for the future. Indigenous knowledge can offer unique and valuable insights that'll help us cope with the environmental changes to come. "The complex dynamics of First Nations people responding to rapidly changing climates lends growing weight to the call for more Indigenous-led environmental management," says Norman.

"As we face an uncertain future together, deep-time Indigenous knowledge and experience will be essential for successful adaptation." **SF**

by **DR CLAIRE ASHER**

Claire is a science journalist with a PhD in biology. Her first book, Brave Green World: How Science Can Save Our Planet *(MIT Press), is out now.*

THE BIG QUESTION

Fast radio bursts: Are these mysterious signals from deep space getting even stranger?

New discoveries are shaking up what little we thought we knew about fast radio bursts

by TOM HOWARTH

Fast radio bursts (FRBs) are among the greatest cosmic enigmas of our time. First discovered in 2007, these fleeting flashes of radio waves have been puzzling astronomers ever since. Despite detecting thousands of them, we still don't know exactly what causes them, where they come from or why they behave so unpredictably.

Just when scientists thought they were beginning to piece together the puzzle, two new studies, published in January this year, threw a spanner in the works, challenging previous theories and adding new layers of intrigue to the FRB mystery.

"FRBs are one of these mysteries of the Universe that deserves to be solved," says Dr Tarraneh Eftekhari, a radio astronomer at Northwestern University, in the US, and lead author of first of the new papers published in *The Astrophysical Journal Letters*. A solution may well be long overdue, but the Universe, it seems, isn't giving up its secrets just yet.

> **"An FRB that's one millisecond long could emit the same amount of energy as the Sun produces in three days"**

WHAT'S SO MYSTERIOUS ABOUT FRBS?

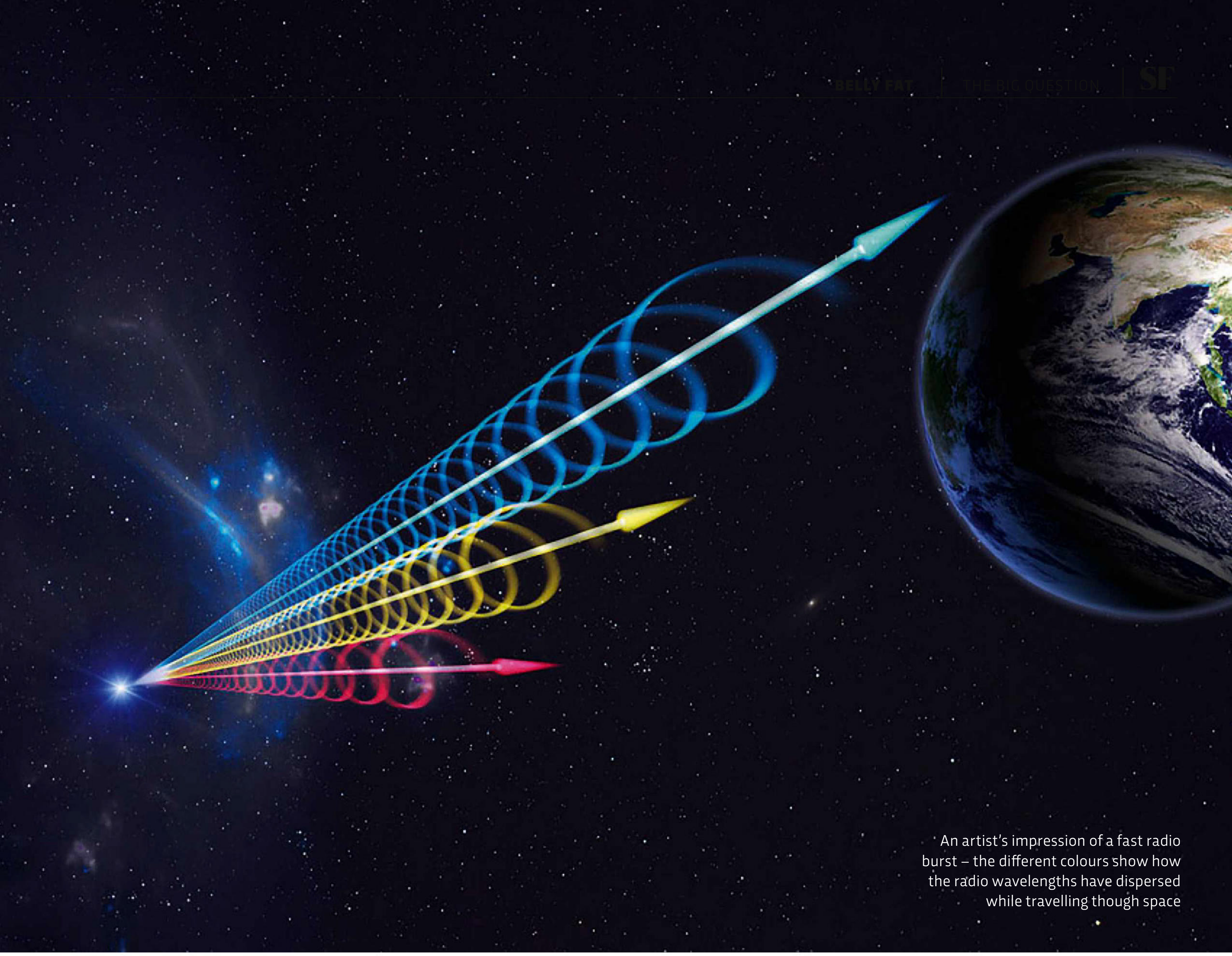
While it wouldn't be quite right to say that FRBs were discovered by accident, it's true that when first spotted, they were buried within data collected for an entirely different purpose: tracking down pulsars.

Pulsars, or 'pulsating radio sources', are a far better understood cosmic phenomenon. They were discovered in 1967 by Prof Jocelyn Bell Burnell and are known to originate from neutron stars – the incredibly dense remnants of massive stars that boast magnetic fields trillions of times stronger than Earth's. These fast-spinning stellar corpses emit regular pulses of radio waves, acting like cosmic lighthouses.

The regularity of the pulses Bell spotted, and the fact they were being emitted at a very specific frequency, hinted that they might be artificially, rather than naturally, generated and led her to nickname that first pulsar "Little Green Man 1". But while pulsars quickly found their place in the astrophysical playbook, FRBs are a different story.

Fast-forward 40 years to 2007, when astronomers poring over data from the Parkes Multibeam Pulsar Survey

JINGCHUAN YU/BEIJING PLANETARIUM/NRAO



An artist's impression of a fast radio burst – the different colours show how the radio wavelengths have dispersed while travelling though space

(an international collaboration between groups at Jodrell Bank Observatory, the Massachusetts Institute of Technology, Bologna Astronomical Observatory and the Australia Telescope National Facility) stumbled upon something entirely unexpected: an ultra-short, incredibly bright burst of radio waves from deep space. This emission was so powerful that it outshone all other known sources at the time by a truly colossal amount.

"In terms of energy output, an FRB that's one millisecond long could emit the same amount of energy as the Sun produces in three days," says Dr Fabian Jankowski, an astrophysicist specialising in FRBs at France's National Centre for Scientific Research.

Yet, for more than five years after this first detection, no others were found, leading some to question whether FRBs were real at all. That scepticism faded as more began to surface. Since then, thousands have been detected, though astronomers estimate that two to three FRBs could be flashing across the sky every minute – suggesting we're only aware of a fraction of the full amount.

Mysterious signals from deep space, emitting mind-boggling amounts of energy, filling the sky. So far, so strange. But the strangeness doesn't end there.

Initially, FRBs were thought to be one-off events – cosmic flukes, appearing once and never again. This assumption seemed solid; despite countless hours of follow-up observations, none of the sources ever repeated.

That changed in 2016, when an FRB known as FRB 121102 was spotted emitting repeated bursts. It's now thought that between 3 and 10 per cent of FRBs are so-called 'repeaters'. Why some FRBs emit a single burst and then remain stubbornly silent, while others emit multiple bursts is yet another mystery waiting to be solved.

WHAT'S CAUSING FRBS?

There are plenty of theories about what FRBs could be, from cataclysmic black hole collisions to aliens (even astronomers accidentally detecting meals cooking in their microwaves). But one candidate currently stands head and shoulders above the rest.

"We know that when very massive stars collapse and go supernova, they leave behind these highly magnetised neutron stars, or 'magnetars'," says Eftekhari. "The reason why magnetars are such compelling candidates for FRBs is that we've detected FRB-like events from a known magnetar that's in the Milky Way."

Neutron stars already boast incredibly strong magnetic fields, but magnetars exist in a league of their own, with fields thousands of times more powerful than an ordinary neutron star.

Adding to the weight of evidence stacked in magnetars' favour is that →

→ most FRBs are found in galaxies with high rates of star formation. This is key because, as Eftekhari says, "you need massive stars to go supernova and leave behind magnetars. And you find massive stars in galaxies that are producing stars."

So, case closed, right? Not quite. This is where the two new studies published in January come in, both of which focused on a repeating FRB known as 20240209A.

"The first exciting thing about this FRB is that it was located way outside of its galaxy," says Vishwangi Shah, a PhD student at McGill University in the US, and lead author of the second paper. "There's only one other FRB that has been localised outside of a galaxy and for that repeater, we know that it's coming from a globular cluster."

Both Eftekhari and Shah suspect that 20240209A also resides in a globular cluster (a dense collection of old stars that linger on the outskirts of a galaxy).

"This was surprising," Eftekhari says. "It kind of challenges the magnetar progenitor idea because you would really need a population of young stars to be producing magnetars."

But what does all this mean for FRBs? One possibility is that magnetars are still the culprits, but they could be forming through a completely different process. For instance, two normal neutron stars might merge in these stellar graveyards, creating a magnetar. Alternatively, a white dwarf – the remnants of a star too small to become a neutron star – could accrete matter from a nearby partner, eventually triggering a massive explosion and leaving a magnetar behind.

Ultimately, though, no one really knows what's behind these outlier events. "It's just exciting to think that we might be dealing with subpopulations of FRBs here," Eftekhari says. "The case isn't as clear-cut as it had started to seem."

> **"There's only one other FRB that has been localised outside of a galaxy and for that repeater, we know that it's coming from a globular cluster"**

by **TOM HOWARTH**
Tom is a freelance science writer and was previously a science communicator at the European Southern Observatory.

The CHIME radio telescope, in Canada, detected FRB 20240209A, which may have come from a globular cluster

WILL WE EVER KNOW WHAT AN FRB IS?

Despite nearly two decades of research, many questions about FRBs remain. What objects are responsible for them? What processes drive these events? And why do some FRBs repeat while others don't?

Answers may be closer than we think, thanks to upcoming advances in the field of FRB detection.

The recent discovery of 20240209A was made using the Canadian Hydrogen Intensity Mapping Experiment (CHIME), a new type of radio telescope that's already detecting two to three FRBs a day – more than any other telescope. CHIME is currently undergoing upgrades that'll allow it to pinpoint bursts with unprecedented precision.

This ability to locate FRBs marks a major step forward in solving the mysteries surrounding them. While many FRBs have been detected, only a handful have had their environments precisely identified, leaving key questions about their origins unanswered. Jankowski believes we'll uncover many more cases like 20240209A in the years to come, potentially unlocking the mechanisms behind them. "I think we'll make huge progress," he adds.

The Square Kilometre Array (SKA) – a massive observatory spanning Australia and South Africa – is also set to join the hunt for FRBs in the near future. Eftekhari and Shah have also submitted a proposal to use the James Webb Space Telescope to investigate the region where 20240209A was detected, in hopes of confirming whether it did come from a globular cluster after all.

"It's a really exciting time in the study of FRBs," Jankowski says. "We could be getting some really major discoveries in the next few years." **SF**

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Q&A

YOUR QUESTIONS ANSWERED

LUKE GILLESPIE, SUNDERLAND

DOES YOUR NAME AFFECT YOUR PHYSICAL APPEARANCE?

Spare a thought for parents-to-be who are agonising over what to name their little bundles of joy. Because, according to new research, it does indeed seem that your name can affect your face. Eventually.

The inspiration for the new research was a finding dubbed the 'face-name matching effect'. It refers to the phenomenon where people seem to be able to look at a person's face and then identify their name from a list of options with surprising accuracy – better than if they were simply guessing.

This raises a couple of possibilities. Either, parents see their infant's face and then give them a name that matches it in some way. Or, our names affect our appearance, so that we end up resembling our name in a way that observers can detect.

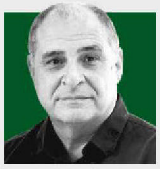
A team of Israeli researchers tested these two explanations in a series of studies in 2024. In one, they asked participants to match the faces of adults and children with their correct names. The participants achieved better-than-guesswork results for the adult faces, but struggled when it came to matching the children's faces with their names. These results suggest that we gradually come to look like our name over time, rather than simply being given an apt name at birth.

Another of the studies used machine learning to assess the similarity of the faces of people who share the same name versus those who don't. This showed that adults with the same name exhibited enhanced facial similarity, but this was not true for children who shared the same name. This is consistent with the idea that we come to resemble our names over time.

But could our names shape our facial appearance? The researchers think that people probably internalise stereotypes

DR CHRISTIAN JARRETT
Psychology

DR ALASTAIR GUNN
Astrophysics



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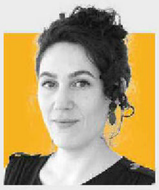


CERI PERKINS
Environment

> "AT THE SAME TIME, OTHER PEOPLE MAY ACT ON THE STEREOTYPES INVOKED BY OUR NAMES, INFLUENCING THE EXPERIENCES WE HAVE"

associated with their name and, over the years, they act in ways that alter their appearance to fit their name.

For example, take a name like 'Tyler' that has masculine connotations in some cultures. A boy given this name might internalise these assumptions and live up to them, adopting sports and outdoor activities – his name might even give him confidence in his social interactions. In turn, his lifestyle and confident facial expressions could slowly sculpt a 'Tyler-like' athletic-looking face and jawline.

At the same time, other people may act on the stereotypes invoked by our names, influencing the experiences we have. For example, if a teacher noticed a link between a certain name and a disruptive nature, they might show prejudice towards a child with that name, which in turn could give the child a negative view of school.

These explanations are consistent with prior research showing your name can affect your experiences – for instance, people with a less popular name (such as Kevin versus Alexander, according to a German study from 2011) are less likely to be successful in online dating; or to receive help from a stranger (according to another German study that used Cindy and Chantal as unpopular names, and Sophie and Marie as popular ones). There's even research that suggests having a rarer name is linked with increased odds of ending up in a more unusual career. ***CJ***

GETTY IMAGES X2 ILLUSTRATION: JESS LEE

BRUCE MCKENZIE, VIA EMAIL

DOES ANYTHING EXCRETE GOLD?

Scientists have identified several bacteria that consume metal compounds and excrete nuggets of pure gold. For example, *Cupriavidus metallidurans* thrives in soils contaminated by toxic heavy metals.

To survive in this harsh environment, the bacterium produces enzymes that protect its cells from toxic copper and gold compounds, producing nanoparticles of pure gold as a by-product. This process allows *C. metallidurans* to live in environments that are poisonous to most lifeforms.

Researchers hope the bacterium's chemical toolkit could be used to refine gold from ores containing tiny amounts of the metal, or to help prospectors detect gold in soil samples. ***CA***

HELEN MARRIOTT, VIA EMAIL

HOW OLD IS JUPITER'S GREAT RED SPOT, REALLY?

Recent research suggests the age of the Great Red Spot – the huge anticyclone vortex in Jupiter's atmosphere – formed about 190 years ago. Scientists base this on historical measurements of the storm's size and motion.

Although the Great Red Spot was first reported by Giovanni Cassini in 1665, and was subsequently observed by many astronomers, there are no reports of a sighting between 1713 and 1831. As such it's unlikely that Cassini's spot is the same one we observe today, which goes to show just how dynamic Jupiter's atmosphere can be. ***AG***

THE ASIAN PALM CIVET

The world might have paid little attention to the Asian palm civet, were it not for the Dutch settlers who planted coffee trees on the islands of Java, Sumatra and Sulawesi, some 300 years ago.

Before then, this long-bodied, short-legged, tree-climbing mammal dined on the islands' fruits, berries, small mammals and insects. But as the coffee plants grew, the cat-like creatures found they had a new delicacy to try. Coffee cherries are the small, round fruit that grow on coffee plants, and contain the beans that we know and love.

The civets tried them, liked them, and when the plantation owners realised that the beans passed straight through the animals, they instructed their workers to scoop the civets' poop and sift out the beans. Waste not, want not, after all.

Then a bizarre thing happened. People tried the coffee made from the civets' recycled beans and they liked it. It had a unique flavour, that's been described as chocolatey, syrupy, earthy and musty, with 'jungle' undertones. And so, Kopi Luwak coffee was born.

While the civets remain in South and Southeast Asia, the unusual coffee is now exported all over the world, and because of its unusual provenance, Kopi Luwak has become one of the most expensive coffees you can buy. A cup of wild civet coffee retails for anywhere between $20 to $100 (approx £15 to £80). But is it worth it?

In the wild, civets are thought to choose the most ripe and perfect coffee cherries, a selection process that helps to improve the coffee's flavour. Then, as the bean passes through the animals' digestive tracts, enzymes and gastric juices cut through the cherries' outer layers and break down internal proteins. This further refines the flavour and aroma of

"PEOPLE TRIED THE COFFEE MADE FROM THE CIVETS' RECYCLED BEANS AND THEY LIKED IT"

the coffee beans. Good for coffee drinkers, but not so good for the civets.

Asian palm civets are predominantly solitary beasts that only come together to mate. They're also deeply territorial and use scent to communicate in the form of faeces, urine and a pungent, waxy substance released from specialised glands near the anus.

With a white mask across the forehead of their otherwise dark faces, their mottled and cryptic fur helps to camouflage them among the dappled shadows of the forests where they live. And like all wild animals, they like nothing more than to be left alone to lead a wild life.

But growing demand for Kopi Luwak coffee is fuelling the rise of Asian palm civet farms. Wild animals are being captured and confined to small battery cages, where they're force-fed coffee cherries and little else. Deprived of a proper diet, exercise and space, most don't last long, so while the rich enjoy a cup of Kopi Luwak, wild civet populations in Indonesia are suffering.

Although there's a quota on the number of civets that can be removed from the wild in Indonesia, it's largely ignored by hunters and not enforced by authorities. All this for a cup of coffee. ***HP***

ALAMY, SHIBAI XIAO/NATUREPL.COM, GETTY IMAGES

CLAUDINE BEST, DORSET

ARE SATELLITES BURNING UP IN THE ATMOSPHERE BAD FOR THE ENVIRONMENT?

About 13,000 satellites currently orbit Earth, roughly 10,000 of which are operational. But that number is set to skyrocket, with a staggering 50,000 new satellites on track to join them by 2030.

The dramatic increase is due to the rise in internet-beaming megaconstellations of satellites, such as SpaceX's Starlink. Out of almost 8,000 satellites now in low Earth orbit (altitudes typically below 2,000km or 1,200 miles), nearly 6,500 are Starlink satellites. SpaceX already has the go-ahead to deploy 12,000 satellites and is seeking approval for 30,000 more. Meanwhile, other companies, including Amazon, are planning megaconstellations of their own.

The upshot: low Earth orbit is becoming increasingly cluttered. As well as raising the likelihood of collisions, there's mounting concern among scientists that megaconstellations could damage the critical layer of ozone that shields Earth from harmful UV radiation.

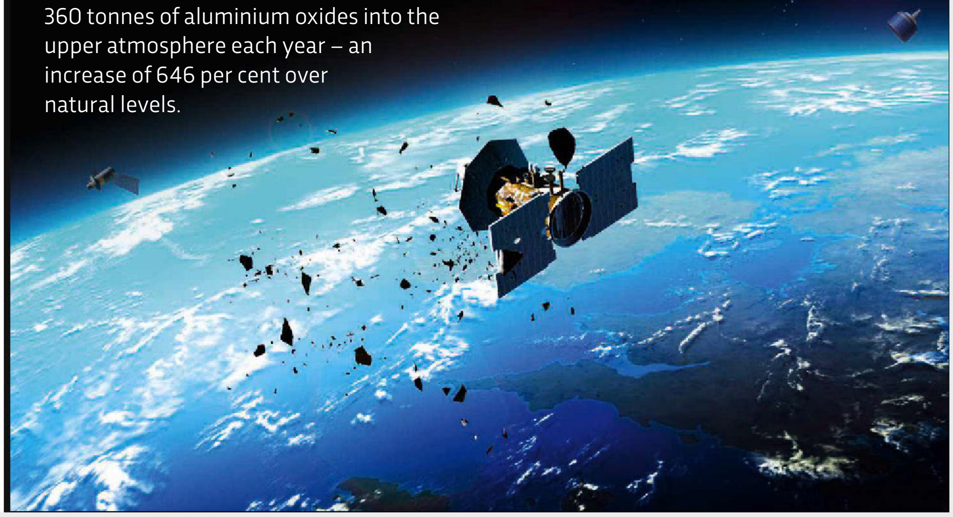
Decommissioned satellites burn up as they re-enter Earth's atmosphere, releasing tiny particles of aluminium oxide. These particles are potent catalysts for chemical reactions that eat away at the ozone layer. But the particles aren't consumed in these reactions, so they can spend decades destroying more and more ozone.

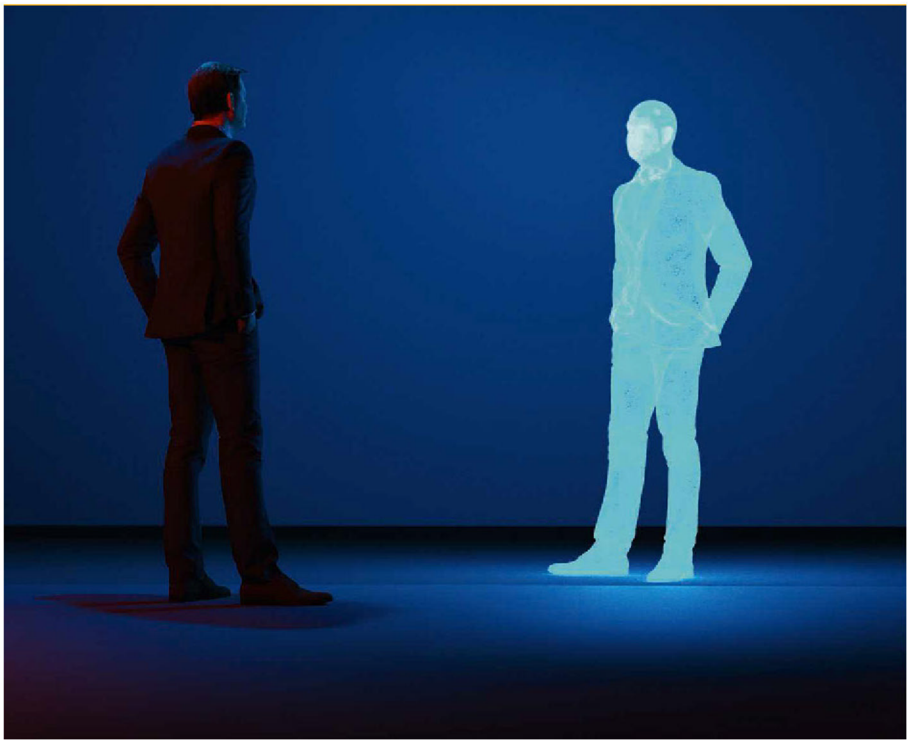
A typical 250kg (550lbs) satellite generates around 30kg (66lbs) of aluminium oxide particles, according to research published in 2024 in the journal *Geophysical Research Letters*. By the time the planned megaconstellations are fully deployed, decaying satellites could inject 360 tonnes of aluminium oxides into the upper atmosphere each year – an increase of 646 per cent over natural levels.

Part of the problem is that internet satellites in low Earth orbit are incredibly short-lived. Starlink satellites, which orbit at about 550km (340 miles), would be pulled out of orbit by atmospheric drag within five years if SpaceX didn't proactively deorbit them first. The company is then compelled to launch new satellites to replace them, perpetuating the cycle. Scientists project that dozens of satellites will be retired each day over the coming decade, potentially releasing a continuous stream of burnt-up materials into the atmosphere. By comparison, the average week saw around 12 re-entries in 2023 (up from just 1.3 in 2019).

It'll take decades to see the full impact of today's satellite re-entries on the ozone layer. Dying satellites create aluminium oxide particles in the mesosphere, 50–85km (30–50 miles) above Earth's surface. But the particles take up to 30 years to drop to the mid-stratosphere (15–30km/about 10–20 miles), where the ozone layer is located.

For now, the impact of satellite combustion on the ozone layer is likely fairly small, but the rapid proliferation of megaconstellations could derail decades of international collaboration to repair the ozone hole. What's missing so far is definitive, in-situ measurements that directly link deorbiting satellites to ozone destruction. An upcoming study by a group that includes Airbus, the Secure World Foundation and the University of Southampton will be the first to collect such data and quantify the risk. ***CP***





JULIAN FISHER , VIA EMAIL

HOW EASILY COULD AI CREATE A DIGITAL DOPPELGÄNGER OF ME?

All too easily.

Generative artificial intelligence (AI) tools have been learning to create faces for decades. In fact, faces were the first thing used to test their abilities, for several reasons. For one thing, faces are similar in structure and layout – great for those early AIs to learn from. There's also plenty of pictures of faces available online. And more data means it's easier for the AI to learn.

But faces were also chosen due to our familiarity with them, which is key for judging the AIs' work. The human brain recognises and understands faces extremely well, but may struggle to tell if the details in an AI-generated image of a landscape or building are correct. As such, research papers that demonstrated AIs

PETRA BELL, PETERBOROUGH

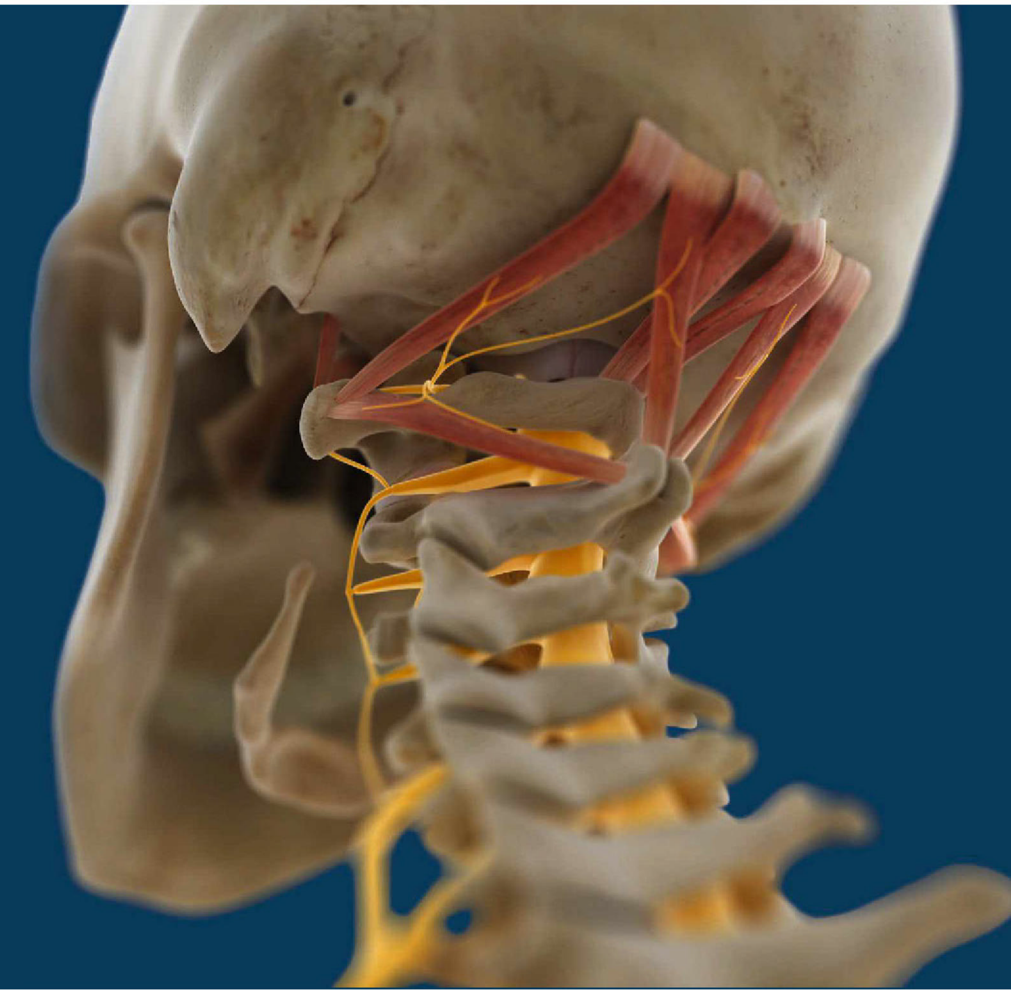
WHAT IS THE HEADACHE BONE AND CAN YOU REALLY 'WORK IT' TO REDUCE HEADACHES?

You might have heard people talk about the 'headache bone', that spot at the base of your skull where headaches seem to brew. But it's not actually a bone causing the problem.

Although that area involves the occipital bone, it also involves a group of small muscles called the suboccipital muscles (the pink fibres attached to the skull and spine, right).

These muscles help you move your head and keep good posture, but when they're tight or overworked, they can trigger tension headaches or neck-related pain. There are things you can do to help alleviate it though:

1. POSTURE Slouching or spending hours hunched over a screen puts strain on these muscles. Keep your head aligned with your spine – imagine a string pulling you up from



capable of generating realistic fake faces always attracted attention.

The result is that over the years, AIs have become specialists in faces. Today they're so proficient that they can take a live video of your face, figure out exactly where all the features lie and seamlessly swap them with another pre-learned face. Perhaps of a celebrity or a politician. You can alter the lighting or even pull silly faces and those effects will be convincingly duplicated by the 'deepfake' face.

Alternatively, given a few images of your face from various angles to use as training data, an AI can generate a double of your face to overlay onto someone else's. With an AI doppelgänger like this, anyone can effectively become you. And it costs nothing – the technology is freely available to anyone with the know-how to install and run it on an ordinary computer.

Creating a digital doppelgänger today might need a certain level of proficiency, but it won't be long before you'll find software out there that anyone can use. These are scary times for privacy and authentication. ***PB***

the top of your head. Make sure you have a good chair, and check your desk height and position to see if that's contributing.

2. SLEEP The wrong pillow can make things worse. Look for one that supports the natural curve of your neck. If you sleep on your back, a contoured pillow might work better for you. You might need to try a few different ones to see what helps.

3. STRETCHES Simple moves such as chin tucks (gently pull your chin towards your neck and hold it there for five seconds) or slow neck rolls can help to loosen up tight muscles.

4. MASSAGE A little pressure in the right place can work wonders. Use your fingers, or even a tennis ball, to massage the base of your skull.

5. BREAKS If you spend long periods sitting, make time to stand, stretch and reset your posture. Small changes can prevent those muscles from tightening up in the first place.

Making small changes to how you sit, sleep and move can make a big difference. But if headaches keep cropping up, it's worth chatting with a doctor to dig deeper. ***NM***

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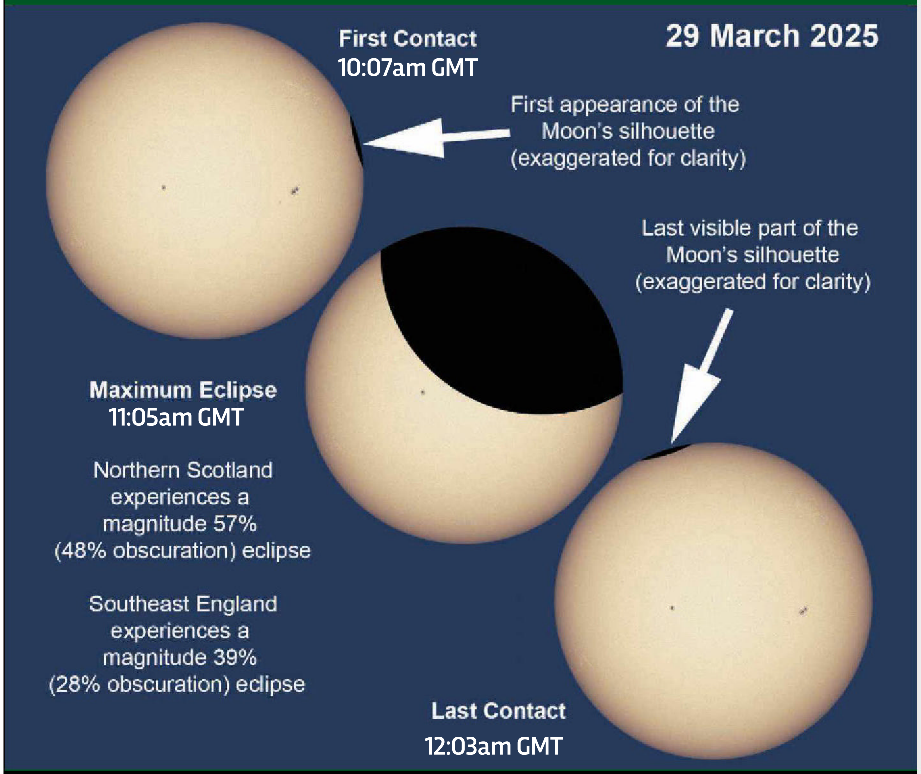
ASTRONOMY FOR BEGINNERS


29 March 2025
First Contact
10:07am GMT
First appearance of the Moon's silhouette (exaggerated for clarity)
Last visible part of the Moon's silhouette (exaggerated for clarity)
Maximum Eclipse
11:05am GMT
Northern Scotland experiences a magnitude 57% (48% obscuration) eclipse
Southeast England experiences a magnitude 39% (28% obscuration) eclipse
Last Contact
12:03am GMT

HOW TO SAFELY VIEW THE PARTIAL SOLAR ECLIPSE

WHEN: 29 MARCH 2025

A partial solar eclipse takes place on 29 March, with a decent amount of the Sun's disc being hidden by the Moon, as seen from the UK. The northern part of Scotland should see the largest eclipse, while those in the southeast of England will see the least (conditions permitting).

Two values describe how much of the Sun is hidden during a partial solar eclipse: magnitude and obscuration. Magnitude describes how much of the Sun's apparent diameter is covered by the Moon; obscuration describes how much of the Sun's area is covered. Both values are given as percentages.

Whenever the Sun is involved in viewing, precautions need to be taken to protect your equipment and, more importantly, your eyes. One of the safest ways to observe an eclipse, is to make a 1–2mm hole in a piece of stiff card and use it to project an image of the Sun onto a piece of white paper, acting as a screen. You'll probably need to keep the hole a metre or so (about 3ft) from the screen. The projection is actually an image of the Sun and will show the shape of the eclipse as the event progresses.

For direct viewing, you'll need to use a certified solar safety filter. For eyes, this normally means a pair of eclipse glasses, which can be bought from astronomical stockists. To protect telephoto lenses or telescopes, it's usual to get certified solar filter sheets which can then be cut to size. Always follow the manufacturer's instructions to make sure they're fitted correctly.

Don't use any non-certified filters you may have lying around – a piece of welding glass, for example. The reason for this is they may allow unseen wavelengths through that could damage your equipment or eyes. Always play it safe when observing the Sun. ***PL***

by PETE LAWRENCE
(@Avertedvision)
Pete is an astronomy expert and presenter on The Sky at Night.

WATCH *THE SKY AT NIGHT* ON BBC FOUR AND BBC IPLAYER

BBC FOUR

LORI COHEN, VIA EMAIL

WHY DO I FIND IT SO DIFFICULT TO SWITCH BETWEEN TASKS?

First, the good news is you're not alone – most people are terrible at task switching. Secondly (and in even more good news), psychologists have been studying it for decades to figure out why.

In an ideal world, we'd focus on one task at a time – get it finished and, only then, move onto something else. Real life is rarely so convenient, however. It's all too common for you to be making great progress on one thing, when… BAM! You suddenly need to deal with something else. If you're working from home, there might be even more tasks to switch between, from signing for deliveries to emptying the dishwasher.

When you do eventually return to the original task, it's likely to take you a while to ease back into it and, at least at first, your performance will probably be poorer.

In the lab, researchers have shown that people are slower and make more errors when they switch back and forth between two tasks, compared with when they focus solely on one.

Giving people a break between the two tasks helps, which suggests that part of the difficulty of task switching is the need to mentally change gears. The break helps with that, but it's not enough, implying there's some lingering interference between the two tasks.

Psychologists call this problem "attentional residue" – essentially, when you switch between tasks, your mind struggles to fully let go of each one before moving onto the next.

Yet another factor has to do with memory – after switching tasks, you have to remember to return to what you were doing originally and where you were at.

Finally, there's also an emotional element, especially when a task switch is forced on you by an interruption. A switch such as this causes frustration and stress, which can also harm your performance. **CJ**

CAMILLA MILLS, KENT

WHAT'S THE CRAZIEST THING EVER STOLEN?

Most robberies involve the sort of goods you would typically expect – jewellery, electronics, or just plain old cash. But some thieves set their sights on rather more unusual loot. Here's some of the strangest things ever stolen.

WHITE GOLD

In 2022, thieves made off with 60 containers of bull semen from a farm in Olfen, Germany. It might seem like a strange thing to steal, but bull sperm is an extremely valuable commodity, used for the artificial insemination of cows. (In the UK, 75 per cent of dairy cattle breeding is done via artificial insemination.) Sometimes called 'white gold', bull semen can sell for tens of thousands of pounds per millilitre. The thieves must have come prepared, because semen needs to be supercooled in liquid nitrogen at -196°C (-320°F) to prevent it from spoiling.

CREEPY CRAWLIES

7,000 live animals were stolen from the Philadelphia Insectarium and Butterfly Pavilion in Pennsylvania in 2018. The loot included glow spot cockroaches, tarantulas and leopard geckos, with a total estimated value of $50,000 (approx £40,000). But the thieves may have been motivated by more than just money. A key piece of evidence left at the scene was a set of staff uniforms, hung from a wall by knives. This led the museum's CEO to conclude that the suspects were disgruntled employees from the animal care department, but the perpetrators were never caught.

OLD X-RAYS

In 2013, a pair of thieves were caught stealing 15,000 X-rays from a hospital in Detroit. The stolen X-ray films were produced prior to 2005 when the hospital's system went digital. X-ray film contains crystals of silver bromide, which are converted to opaque silver atoms when the film is developed to create a visible image. The silver content is probably what attracted the thieves to steal the X-rays, but they may not have been aware that the

process of extracting silver from X-ray films is very expensive.

A COMMERCIAL AIRCRAFT

The 2003 theft of a Boeing 727-223 airliner prompted a global search and left US intelligence agencies on high alert. The aircraft was stolen from Quatro de Fevereiro Airport in Angola by a US flight engineer and a mechanic from the Republic of Congo. Without communicating with the air traffic control tower, the plane took off with its lights and transponder turned off, and headed towards the Atlantic Ocean. The thieves haven't been seen since and the plane, or any debris from it, has never been recovered. Their motive was never conclusively determined, but authorities believe it may have been an elaborate insurance fraud scheme.

BEE HIVES

Hundreds of bee hives were stolen from a beekeeper in California in 2017. Honeybees are valued for their pollination services, which are essential to California's booming almond farming businesses. The lead suspect in the case was found in possession of 2,500 stolen hives taken from farms across the state, worth an estimated $875,000 (almost £695,000). Beekeepers often mark their equipment with a unique symbol, which helped the authorities to identify the stolen loot. ***CA***

GETTY IMAGES X2 ILLUSTRATION: JESS LEE

QUESTION OF THE MONTH

DILEEP BAGNALL VIA EMAIL

WHAT ARE EARLOBES FOR?

Earlobes may seem like a simple, often overlooked, part of our anatomy, but they serve a few interesting purposes. Some people think earlobes improve our ability to detect sound, because the fleshy lower part of the ear helps to funnel sound waves into the ear canal. But other scientists argue they don't have any true biological purpose.

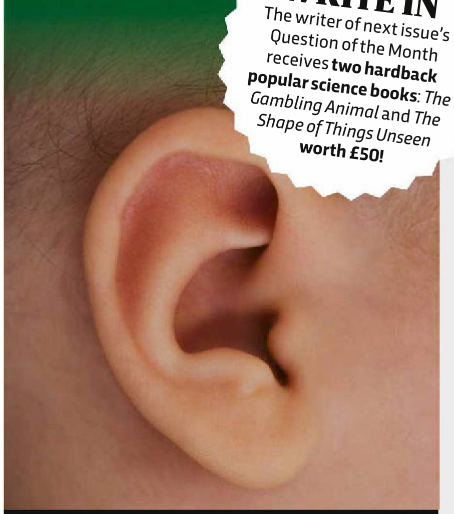
What we do know is that earlobes are rich in nerve endings, making them sensitive to touch. This may play a role in social bonding and communication through physical contact, such as gentle touches or pulling in certain cultural practices.

While earlobes don't have a critical function like some other body parts, they have cultural significance in many societies. They are often adorned with jewellery and are involved in traditional practices like ear stretching or piercing. So, while their role in physiology might be modest, their contribution to human expression and culture is significant. ***NM***

The Gambling Animal
The Shape of Things Unseen

WRITE IN

The writer of next issue's Question of the Month receives **two hardback popular science books**: *The Gambling Animal* and *The Shape of Things Unseen* **worth £50!**



EMAIL YOUR QUESTIONS TO
QUESTIONS@SCIENCEFOCUS.COM

This was Sylvia's promise to you...

A generation ago, a woman named Sylvia made a promise. As a doctor's secretary, she'd watched stroke destroy the lives of so many people. She was determined to make sure we could all live in a world where we're far less likely to lose our lives to stroke.

She kept her promise, and a gift to the Stroke Association was included in her Will. Sylvia's gift helped fund the work that made sure many more of us survive stroke now than did in her lifetime.

Sylvia changed the story for us all. Now it's our turn to change the story for those who'll come after us.

Stroke still shatters lives and tears families apart. And surviving a stroke is just the start of a long and gruelling recovery journey. If you or someone you love has been affected by stroke – you'll know just what that means.

You can change the story, just like Sylvia did, with a gift in your Will. All it takes is a promise.

You can promise future generations a world where researchers discover new treatments and surgeries, and stroke survivors and their families have the support to find the strength and determination they need to find their way back to life.

Your promise today gives strength for tomorrow. Please, leave a gift in your Will to the Stroke Association.

Find out how by calling 020 7566 1505
or email legacy@stroke.org.uk
or visit stroke.org.uk/legacy

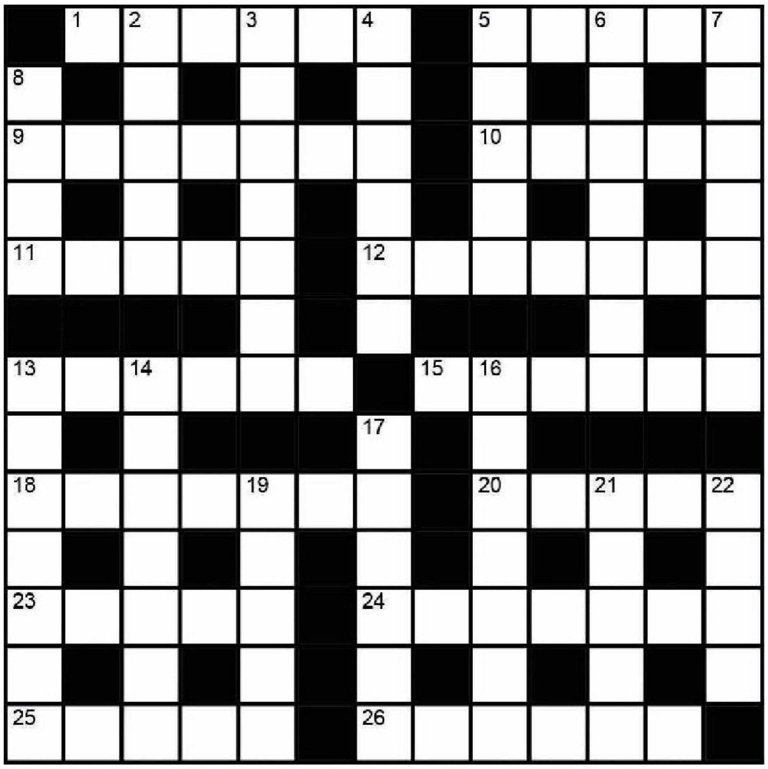
Finding **strength** through **support**

The Stroke Association is registered as a charity in England and Wales (No 211015) and in Scotland (SC037789). Also registered in the Isle of Man (No. 945) and Jersey (NPO 369), and operating as a charity in Northern Ireland.

Stroke Association

CROSSWORD

PENCILS AT THE READY!



ACROSS

1 Worried assistance will follow far off (6)
5 Terribly bored, but dressed (5)
9 A Catholic curse about plaintiff (7)
10 Staring at a torn page (5)
11 Commiserated about skinflint (5)
12 Old barrier started to get vandalised (7)
13 Assessing a sailor (6)
15 Frank also seen among detectives (6)
18 Mislay award outside, getting shot (5-2)
20 Line in a letter read out (5)
23 Organised tour around key royal house (5)
24 Revising and changing gin diet (7)
25 Huge order for lager (5)
26 Unexpectedly asleep, if you don't mind (6)

DOWN

2 Concentrate on what a camera can do (5)
3 Loser managed as well (4-3)
4 Ridicule notes on journey (6)
5 More almonds surround field (5)
6 Bishop, in tatters, boasted (7)
7 Right late coming round, journalist is feared (7)
8 Serene local man hides (4)
13 Article about concert (7)
14 Excessively red, moving right as required (2,5)
16 Get a key and some paper (7)
17 At university, retain service (6)
19 Eastern lake is strange and frightening (5)
21 Times changing releases (5)
22 Exaggerated gestures around the side (4)

ANSWERS For the answers, visit **bit.ly/BBCFocusCW**
Please be aware the website address is case-sensitive.

NEXT ISSUE

THE SURVIVOR'S SHOPPING LIST

What you really need in a doomsday bunker

GETTY IMAGES

PLUS

MIND GAMES

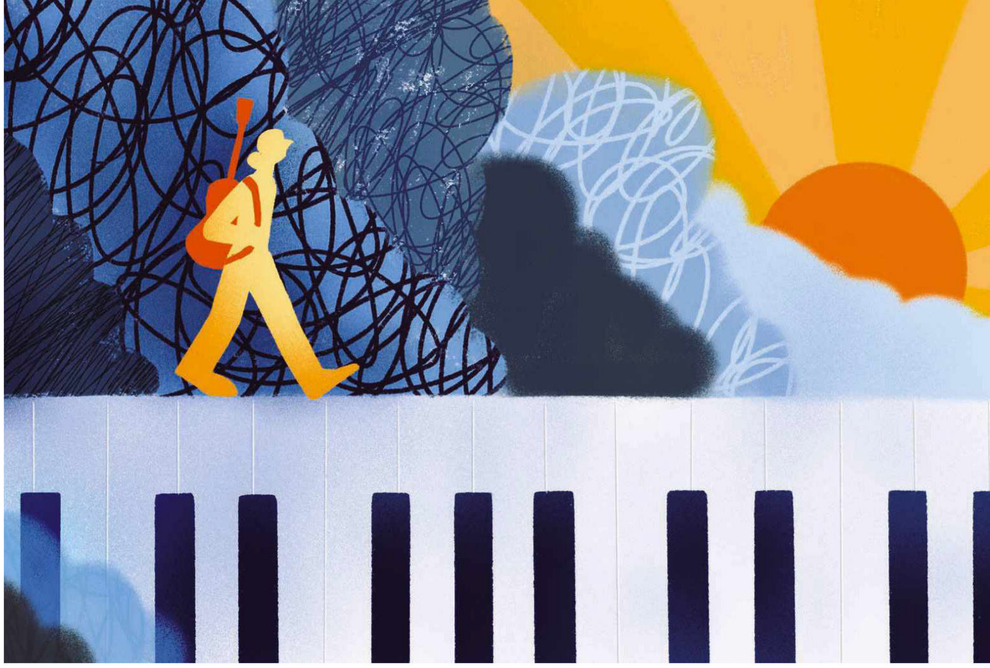
The mental gymnastics that can boost your physical performance

ERUPTIONS BELOW

How volcanoes in Earth's core are changing the planet

ON SALE 15 APRIL

BETTER LIVING THROUGH SCIENCE



HOPE PREVAILS

Optimism trumps mindfulness when things get tough, says the science

by **IAN TAYLOR**
Ian is a freelance science writer and the former deputy editor of BBC Science Focus.

In the last decade or so, mindfulness has been one of the revelations in the science of wellness. Researchers have shown that meditative practice can lower stress, reduce blood pressure, improve sleep and promote good mood.

But there's a but, because in science there's almost always a but. Mindfulness doesn't work for everyone and for some people, it can lead to adverse effects, such as increased anxiety or depression.

Which makes sense. Being present in the moment feels good when the moment in question is generally positive, or neutral. But if you happen to be going through a bad time, mindfulness can serve to increase awareness of your own emotions and exacerbate the psychological problems that come with them.

"I'm drowning here… And you're describing the water!" yells Jack Nicholson in the 1997 film *As Good as it Gets*. He was talking about his love life, but the sentiment holds for mindfulness, too.

So, when mindfulness means a mind full of negative emotions, what mental tools should we reach for instead?

Last year, an interesting study compared mindfulness with a different kind of positive mindset: hopefulness. Researchers at Clemson University and North Carolina State University wanted to know how these different mental states affected people during an unquestionably difficult period.

They spoke to workers in the music industry about their experience of the COVID-19 pandemic. "We deliberately reached out to a group that had been really impacted by the pandemic," says study author Dr Kristin Scott. "Their work was obliterated for a long time.

"We approached this from the mindset of, what helped these individuals stay the course, stay focused, not totally give up, not fall into depression?"

Scott and her colleagues found that hope improved the music workers' resilience and professional engagement. Mindfulness, in contrast, increased job tensions and stress. It was a stark result that begs another question: what exactly is hope?

It might sound like something passive – a blind faith that things are somehow going to be okay. Scott says that's not quite right. To be beneficial, hope has to be something active and proactive, strategic and forward-looking.

"It's quite a goal-oriented mindset," Scott says. "It's saying, 'I don't know how things are going to go, but I feel that if I do these things and if I stay focused, I think that I can get positive outcomes.'

"You don't get so caught up in the noise and distractions of the negative. You put that information more in the back of your mind."

"TO BE BENEFICIAL, HOPE HAS TO BE SOMETHING ACTIVE AND PROACTIVE, STRATEGIC AND FORWARD-LOOKING"

The finding chimes with evidence on the power of optimism. Multiple long-term studies find that optimists live longer, happier lives, and are more likely than pessimists to adopt healthy behaviours.

Scott is keen to stress that although hope led to more positive outcomes in her study, that's not to say there isn't a time and a place for mindfulness.

"Mindfulness isn't bad at all," she says. "It's a calming mechanism. And purists would say there's also mindful acceptance, which is about acknowledging when things are bad, but not letting that get to you. 'I've seen negative stuff and I'm not giving in to that.'

"I think hope just takes it a step further by saying 'I'm actively going to work around these different barriers.'"

Scott can relate – she needed hope and resilience to get the research published. "This is humbling to disclose, but this paper was initially rejected, even at conferences. People were defensive or confused about what we were saying about mindfulness. Honestly, for a while we joked that it was the hopeless paper."

She had another colleague who questioned the idea of false hope, and whether telling people to get their hopes up could be problematic.

"I've been thinking more about that too, but in its pure sense, hope is about asking what you can do instead of falling into pure dejection and helplessness. To me, hope is about staying hopeful, no matter what happens." **SF**

ILLUSTRATION: JESUS ESCUDERO

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The extraordinary new **C1 Moonphase** from Christopher Ward. A watch that tracks the moon for 128 years – without missing a beat. With an aventurine glass dial infused with copper oxide to represent the night sky. And a 3D 'moon' sculpted from Globolight© – a luminous ceramic – that precisely follows the real moon's journey across the sky. A watch this advanced can cost up to £45,000. But the C1 Moonphase starts from less than £2,000. As someone once said, you don't have to be mad to work here...

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